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ARKANSAS - WHITE - RED FIELD STUDIES. ARKANSAS RIVER: SAND SPRINGS, OKLAHOMA TO WEBBERS FALLS, OKLAHOMA. LITTLE ROCK, ARKANSAS, TO PINE BLUFF, ARKANSAS. OUACHITA RIVER: ARKADELPHIA, ARKANSAS, TO RICHARDSON'S FERRY, ARKANSAS. CAMDEN, ARKANSAS, TO COLUMBIA, LOUISIANA

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Environmental Health Center
Cincinnati, Ohio

August 1953

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ARKANSAS - WHITE - RED
FIELD STUDIES

ARKANSAS RIVER

SAND SPRINGS, OKLAHOMA, TO WEBBERS FALLS, OKLAHOMA

LITTLE ROCK, ARKANSAS, TO PINE BLUFF, ARKANSAS

—— O ——

OUACHITA RIVER

ARKADELPHIA, ARKANSAS, TO RICHARDSON'S FERRY, ARKANSAS

CAMDEN, ARKANSAS, TO COLUMBIA, LOUISIANA

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CINCINNATI, OHIO
AUGUST, 1953

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ARKANSAS - WHITE - RED
FIELD STUDIES

ARKANSAS RIVER

Sand Springs, Okla., to Webbers Falls, Okla.
Sept. 22, 1952, to Oct. 10, 1952

Little Rock, Ark., to Pine Bluff, Ark.
July 14, 1952, to July 24, 1952

OUACHITA RIVER

Arkadelphia, Ark., to Richardson's Ferry, Ark.
July 28, 1952, to August 2, 1952

Camden, Ark., to Columbia, La.
August 5,1952, to Sept. 10, 1952

By

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U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER
AUGUST, 1953

I-a

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Arkansas

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ARKANSAS - WHITE - RED
FIELD STUDIES

PART A

GENERAL

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ARKANSAS-WHITE-RED FIELD STUDIES

Introduction

These studies were made at the request of and in co-operation with the Southwest Lower Mississippi Drainage Basins Office, Little Rock, Arkansas. Field operations were conducted by the Environmental Health Center, Cincinnati, Ohio, in co-operation with the States of Arkansas, Louisiana, and Oklahoma.

The studies were divided into four surveys referred to hereafter as follows:

Part (B) Arkansas River - Sand Springs, Oklahoma, to Webbers Falls, Oklahoma; September 22 - October 10, 1952.

Part (C) Arkansas River - Little Rock, Arkansas, to Pine Bluff, Arkansas; July 14 - July 24, 1952.

Part (D) Ouachita River - Arkadelphia, Arkansas, to Richardson's Ferry, Arkansas; July 28 - August 2, 1952.

Part (E) Ouachita River - Camden, Arkansas, to Columbia, Louisiana; August 5 - September 10, 1952.

The primary objectives of the studies were to obtain data on river water quality, especially regarding dissolved oxygen content, chloride content, biochemical oxygen demand, and bacteriological quality, to supplement existing chemical data compiled by the U. S. Geological Survey for the purpose of determining the pollutional effects of municipal and industrial wastes discharged to the streams.

The results of the studies will be used by the respective States in the development of their water pollution control programs and by the Basin Office in connection with its Arkansas-White-Red Basins Inter-Agency Committee activities.

Survey Methods

Sampling Stations - Sampling stations were established, in general, above and below sources of pollution and at intermediate locations considered of importance to show the effects of pollution on the streams. The stations were identified by the distance in miles above the mouth of the river. River mileage data were taken from records of the U. S. Corps of Engineers.

Sampling Procedures - Sampling was usually carried on from a boat though bridges were used whenever possible. Except during special studies samples were taken at midstream at a depth of 2 to 3 feet below the surface. A complete sample taken at a station consisted of standard bottles for dissolved oxygen, biochemical oxygen demand, coliform density and a one gallon portion for other chemical analysis.

For each sample taken, the sample collector recorded such field data as the time of day the sample was collected, the temperature of the sample to the nearest degree centigrade, and noted any unusual stream conditions existing at the sampling station. The samples were transported to the laboratory as quickly as possible in ice cooled carrying cases and subjected to analysis on the same day as received at the laboratory.

Laboratory Facilities - All chemical, physical and bacteriological tests were conducted in a mobile trailer laboratory of the Environmental Health Center. The samples collected in the field for biological analyses were preserved and analyzed at the laboratory of the S. W. Lower Mississippi Drainage Basins Office in Little Rock, Ark.

Laboratory Tests - Routine laboratory tests included dissolved oxygen, biochemical oxygen demand, temperature, nitrate, phosphate, chloride, turbidity, color, coliform group organisms, pH and total alkalinity. All tests were conducted in accordance with the procedures stated in Standard Methods for the Examination of Water and Sewage, 9th Edition, 1946, of the American Public Health Association.

A brief explanation of the routine analytical tests is presented to aid in interpreting the analytical results.

Dissolved Oxygen - The amount of oxygen dissolved in stream water is normally limited by the saturation value (9.17 ppm at 20°C. and 7.6 ppm at 30°C.) which is a function of water temperature. Dissolved salts also influence oxygen solubility. In some cases this saturation value may be exceeded causing "supersaturation." The photosynthetic action of some water plants, including algae, or air entrainment caused by discharging water over spillways, etc., may cause "supersaturation." It is necessary that an adequate quantity of dissolved oxygen be present in stream water to support fish and aquatic life and for natural aerobic purification of water. For support of fish life the amount of dissolved oxygen needed depends upon the species of fish. Species such as carp can live and propagate at reasonably low dissolved oxygen levels while game fish such as trout require stream waters high in dissolved oxygen. Values substantially below the saturation level generally indicate the presence of pollution which is utilizing for stabilization the oxygen from stream water. A measure of pollution in a given area is given by the deficiency in dissolved oxygen content below saturation.

Five-day BOD at 20°C. - The standard biochemical oxygen demand test requires that a sealed sample of the water under examination be incubated for 5 days at a temperature of 20°C. and then the loss of dissolved oxygen during that time be determined. Where the loss may be greater than about three-fourths of the initial dissolved oxygen present, the sample is diluted with standard BOD dilution water and the measured loss multiplied by the appropriate dilution factor.

The BOD thus determined becomes an empirical measure of the amount of dissolved oxygen necessary to satisfy the biochemical oxidation requirements of the pollution present at the time the sample was collected. Since the amount of dissolved oxygen present decreases and the rate of oxidation increases with increasing temperature, critical stream conditions occur during the warm months especially since low stream flows often accompany high temperatures.

Temperature - The temperature of water controls the solubility of oxygen and thus the saturation level of dissolved oxygen in the stream. The rate of oxidation, natural purification, and growth of bacteria, plankton and fishes is increased or diminished with higher or lower temperatures, respectively.

Nitrate as N - Nitrates in water can be attributed to numerous sources, domestic sewage, organic industrial wastes, or even absorption from the atmosphere. It is generally considered that a nitrogen concentration in the magnitude of 0.1-0.3 ppm is a necessary nutrient for the stimulation of algae growth. Algae growth, if excessive, can lead to taste and odor problems.

Phosphate (PO_4) - It is fairly well accepted that phosphorus is a necessary nutrient for the stimulation of most algae growth. The value of 0.01 ppm of inorganic phosphorus is usually accepted as the concentration necessary for most algae growth stimulation. A large majority of the synthetic detergents on the market today contain some form of phosphorus as a complex phosphate.

Chloride (Cl) - All surface waters contain chlorides, the normal amount varying in different regions. An increase in chlorides above normal is usually indicative of pollution from domestic or industrial sources. Excessive chlorides increase the soap consuming properties of water and adversely affect water used for boiler feed water and in heat transfer units.

Turbidity - Turbidity in water is due to suspended material such as silt and finely divided organic material. This suspended material may be particles that will settle out upon standing or it may be colloidal in nature. Turbidity measurement gives an approximation of the silt load or suspended material carried by the stream. There is no direct relation between turbidity and discharge but generally the turbidity is greater at times of high discharge than at times of low discharge.

Color - There are two types of "color" in water that one differentiates between by definition. "True color" is defined as the color in water due to dissolved substances only, the suspended matter having been removed. "Apparent color" includes the color contributed by the suspended material as well as by substances in solution. The color determinations performed in the Ark.-White-Red Field Studies were for "true color."

Coliform Group Organisms - MPN - This test known as the MPN Index is a means of approximating the density of coliform organisms in a stream. The coliform organisms are present in the intestine of man and warm blooded animals. They are present in great numbers in sewage but are relatively few in industrial waste. This test gives a good estimation of the sewage pollution of a stream since natural unpolluted streams contain only a small number of coliform organisms. The results are reported as the "most probable number" (MPN) per 100 milliliters.

pH - pH is defined as the negative lograithm of the hydrogen ion concentration. It is a measure of intensity rather than quantity and indicates relative acidity or alkalinity with the neutral point at pH 7.0 at 25°C. Values lower than 7.0 indicate the presence of acid salts and values ranging above pH 7.0 indicate the presence of alkalies or alkaline earth salts.

Total Alkalinity - Alkalinity represents the concentration of carbonates, bicarbonates, hydroxides and occasionally silicates, borates and phosphates.

Wastes high in alkalinity that are discharged to a stream usually affect the hardness of the stream. Water hardness is an economic factor in the use of a water supply for industrial or domestic purposes.

Biological Studies

Sampling Procedures - Biological investigations consisted of collecting samples of river bottom material for examination of biological life. Generally, one representative sample was collected from each station. In the Louisiana section of the river, however, two samples were collected at each station.

In general, samples of aquatic animals were collected by separating them from bottom material with a No.30 screen (590 micron opening). Since the characteristics of the river bottoms varied greatly, it was not always possible to use the same method of collection. In some cases a quantity of the bottom mud or sand was collected, preserved, and the organisms separated later by other methods. Where the river bottom consisted of gravel and rocks, organisms adhering to the rocks were collected.

Objectives - The objectives of making biological investigations were to determine the kinds of organisms that were present, determine their relative abundance, and correlate this information with chemical and physical data. Review of biological data, together with chemical data and physical factors of the environment, provided information that indicates, in most cases, the extent to which sources of pollution affect the bottom dwelling organisms.

Significance of Observations - Data obtained show that below some of the sources of pollution a variety of organisms grew in prolific numbers where rocky bottoms were favorable for the development of the organisms. At other locations where the river bottom consisted of unstable sand, relatively few organisms developed even though chemical characteristics of the water appeared favorable for their growth. It is important, therefore, that careful consideration be given to the types of bottom material present before comparisons of biological data are made.

The presence in a stream of sensitive organisms such as stoneflies, mayflies, and others, usually indicates that environmental conditions have been favorable for several months or longer. One important environmental factor is an adequate oxygen supply. Abnormally large populations of organisms, including sensitive forms, may develop in stream areas that contain food provided by organic wastes if the stream is well aerated. Other sections of the same stream containing an equal amount of pollution may be unable to support sensitive organisms because reaeration is not adequate to counter deoxygenating effects of pollution present.

For many organisms, the period each season during which eggs are deposited is relatively short. The destruction of organisms may result from pollution that contains toxic substances or that reduces the oxygen concentration in the stream. The absence of sensitive organisms in areas where they are normally found indicates that pollution is present or may have existed during the period of their development.

PART B

ARKANSAS RIVER

SAND SPRINGS, OKLA., TO WEBBERS FALLS, OKLA.

MILE 530 TO MILE 428.4

SEPT. 22, 1952 TO OCT. 10, 1952

Part B

Arkansas River - Sand Springs, Okla., to Webbers Falls, Okla.
Mile 530 to Mile 428.4

Summary

Chemical and Bacteriological - In this reach of the Arkansas River between Sand Springs, Okla., and Webbers Falls, Okla., the greatest amounts of domestic and industrial pollution are contributed at Tulsa and at Muskogee.

Stream characteristics below both Tulsa and Muskogee are such at present that thorough dispersion of the waste introduced into the Arkansas River appears to be complete in a short distance.

The dispersion pattern observed below Tulsa during this survey should not be changed by the construction of the proposed Webbers Falls Dam. It is probable, however, that the dispersion pattern for the Muskogee wastes at low flow conditions will be altered by the installation of the proposed locks and dams on the Arkansas and Verdigris Rivers.

High algae activity was noted in certain stretches of the river. On the basis of special studies made at two points on the river on the variations of dissolved oxygen with time of day, it is believed probable that complete depletion of oxygen occurred during early morning hours at Tulsa, Jenks and Bixby.

A 50% reduction in BOD would be required to maintain a minimum of 4 ppm of dissolved oxygen for the present load discharged to the river - in addition a considerable reduction in coliform organisms would be required to satisfy State requirements. The stream flow necessary for pollution abatement by dilution assuming primary treatment of Tulsa's wastes is 700 cfs.

For future population increase at Tulsa of 25% either a 60% reduction in

BOD and chlorination, or a stream flow of 800 cfs with primary treatment and chlorination for the waste discharged to the stream would be required for pollution abatement.

Biological - In the Arkansas River from Sand Springs to Webbers Falls it was observed that a variety of bottom organisms developed in large numbers when the following conditions existed; (1) the presence of abundant food materials provided by sewage, (2) rapidly flowing water passing over rock bottom that provided aeration and a suitable habitat for developing organisms, and (3) the absence of deleterious materials such as oil or toxic substances.

About five miles below Tulsa, at Jenks, bottom life sensitive to such factors as low oxygen concentrations and toxic materials were not present even though the physical characteristics of the stream were favorable. More tolerant organisms were found. Pollution discharged to the river above Jenks was detrimental and restricted the growth of sensitive biological organisms.

Farther downstream at Muskogee, the physical characteristics of the stream were favorable for the development of organisms. Moderately large numbers of a variety of sensitive organisms were present and it was evident that food materials were abundant and factors of the environment did not interfere with the development of the organisms.

Below Muskogee sewage stimulated the development of sensitive aquatic organisms. Although organisms were present in abundance fifteen miles below the sewage outfalls, their numbers had decreased considerably in the first few miles below the outfalls.

The development of an overabundance of sensitive organisms should be interpreted as an undesirable condition. Although the organisms rapidly consume the food from the sewage pollution an unbalanced biological condition has been created.

Introduction

The survey of the Arkansas River, between Sand Springs and Webbers Falls, was conducted with a two-fold objective in view: (1) to determine water quality using chemical, biological and bacteriological tests; (2) to determine the degree of mixing of sewage from Tulsa and Muskogee with the Arkansas River. During the course of the survey, special studies were performed to determine the effect of algae on the dissolved oxygen concentration in the stream.

Description

General - The Arkansas River between Sand Springs, Okla., and Webbers Falls, Okla. (a distance of 101.6 miles), flows in a southeasterly direction. The drainage area contributing above Sand Springs is 74,350 square miles, while that at Muskogee, Okla., is 96,409 square miles, which includes drainage areas of 8,300 square miles for the Verdigris River and 12,520 square miles for the Grand (Neosho) River. The main tributaries to the Arkansas River in this area are Polecat, Haikey, Snake, Concharty, Coal, Yellow Water, Pecan, Coody and Sapinard Creeks, and the Verdigris and Grand (Neosho) Rivers.

The general area between Sand Springs and Webbers Falls is rolling country with an occasional large hill. The elevation of the river bottom at Sand Springs is approximately 630 ft., while that at Webbers Falls is 460 ft. above mean sea level, a drop of approximately 1.7 ft/mile.

Economic Background - The principal industry in this region is the production and processing of petroleum products. The other industries of any importance are metal plating, chemical manufacturing, glass production and meat and poultry packing firms. Much farming is done in this area, corn, grains and forage being the principal crops. The raising of livestock is prevalent.

Water Uses

Public Water Supplies - The cities of Tulsa and Muskogee obtain their water from surface supplies, Lake Spavinaw and the Grand (Neosha) River, respectively. The towns of Bixby, Haskell, Jenks and Webbers Falls have well water supplies. The high chloride content of the Arkansas River in this region limits the use of its waters.

The proposed installation of the multipurpose reservoir on the Arkansas River at Webbers Falls will probably have an effect on the location of Muskogee's water intake. The intake is located on the Grand (Neosho), approximately 1,000 feet from the confluence of the Grand (Neosho) and the Arkansas Rivers. The pooling of the rivers caused by the Webbers Falls Dam will extend up the Grand (Neosho) River as far as the Ft. Gibson Dam (see figure B-C-1). This will increase the possibilities during periods of low flow, of contamination of the water intake by either the high chloride waters of the Arkansas River, or by the sewage from Muskogee's north outfall discharged at less than two miles upstream from the intake. The installation of the dam at Webbers Falls would necessitate relocating Muskogee's water intake.

Navigation - At the present time there is no commercial navigation on this portion of the Arkansas River. At the time of this survey, it was difficult and hazardous sampling by boat because of low water flow and sections of quicksand.

It has been proposed that a system of locks and dams be installed on the Arkansas River and tributaries for navigation and power purposes, as shown on diagram B-C-1. The installation of these locks and dams, and the multiple-purpose reservoir at Webbers Falls, would make the Arkansas River

PROPOSED LOCKS AND DAMS
GENERAL PLAN
ARKANSAS RIVER AND TRIBUTARIES

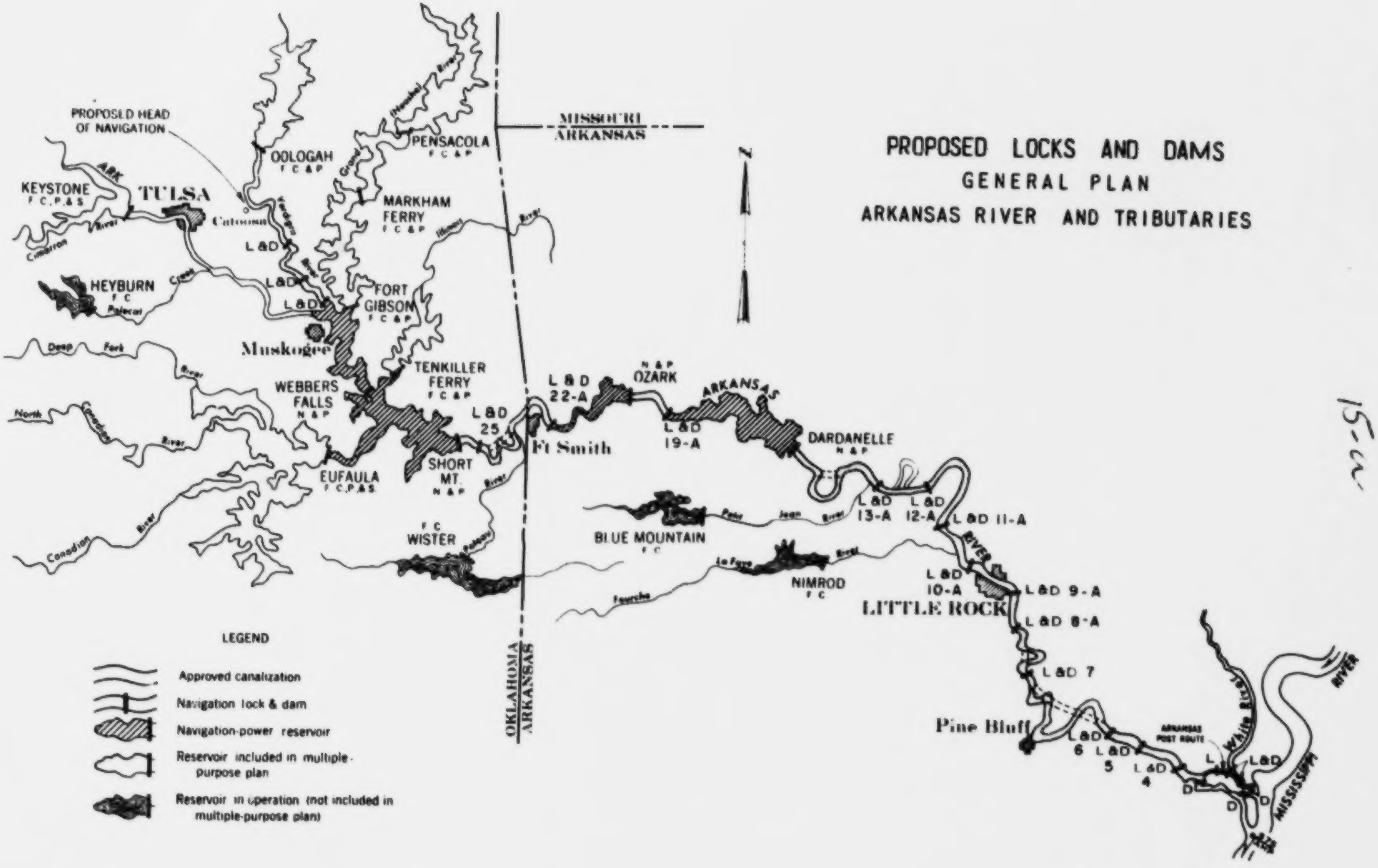

PROPOSED HEAD OF NAVIGATION
KEYSTONE F.C.,P.&S.
ARK
TULSA
Catoosa
Cimarron River
HEYBURN F.C.
Polecat Creek
OOLOGAH F.C.&P.
Verdigris River
L&D
L&D
L&D
Muskogee
Deep Fork River
North Canadian River
Canadian River
PENSACOLA F.C.&P.
(Neosho) River
Grand
MARKHAM FERRY F.C.&P.
Illinois River
FORT GIBSON F.C.&P.
TENKILLER FERRY F.C.&P.
WEBBERS FALLS N.&P.
EUFAULA F.C.,P.&S.
SHORT MT. N.&P.
L&D 25
Poteau River
F.C. WISTER
MISSOURI
ARKANSAS
OKLAHOMA
ARKANSAS
Ft Smith
L&D 22-A
N.&P. OZARK
ARKANSAS
L&D 19-A
DARDANELLE N.&P.
N
BLUE MOUNTAIN F.C.
Petit Jean River
NIMROD F.C.
La Fave River
Fourche
L&D 13-A
L&D 12-A
L&D 11-A
RIVER
L&D 10-A
L&D 9-A
LITTLE ROCK
L&D 8-A
L&D 7
Pine Bluff
L&D 6
L&D 5
L&D 4
ARKANSAS POST ROUTE
White River
L
L&D
D
D
D
MISSISSIPPI
RIVER
LEGEND
Approved canalization
Navigation lock & dam
Navigation-power reservoir
Reservoir included in multiple-purpose plan
Reservoir in operation (not included in multiple-purpose plan)

FIGURE B-C 1

navigable for about 460 miles during low-flow periods from the Mississippi River to above Muskogee, Okla.

Fishing - Although there is very little commercial fishing in this area (the Verdigris River excepted) there is an appreciable amount of sport fishing. According to the local residents catfish are the main variety of fish caught.

Sources of Pollution

Domestic Sewage - Table B-1 is a tabulation of the various communities with regard to the population served by sewers and the estimated population equivalent discharged to streams. Tulsa and Muskogee contribute the greatest amount of domestic pollution in this area.

Industrial Pollution - No estimate has been made of industrial pollution loads discharged to the Arkansas River from the Tulsa and Muskogee areas. The wastes would be mainly of the character discharged from petroleum processing plants and those involved in metal plating, chemical manufacturing, glass production, and meat and poultry packing.

Survey Methods

Location of Sampling Stations - Because of the low flow in the Arkansas River, during the survey, a large majority of the samples had to be taken from bridges. Usually this was satisfactory; however, it was not possible to obtain a sample of the river immediately below all of Tulsa's outfalls. Table B-2 presents a listing of the sampling stations. Plate B-2 shows their location on the Arkansas River.

Normal Sampling Procedures - A standard copper, one-gallon capacity, 3-bottle sampler was used for taking samples. Samples were taken at mid-depth, which ranged between 1 ft. to 2 1/2 ft. at the sampling stations.

Special Sampling Procedures

Diffusion Studies - Immediately below the outfalls of Tulsa and Muskogee, top and bottom sampling was performed to determine the degree of vertical mixing.

Effect of Algae on Dissolved Oxygen - To determine the effect of algae activity on the dissolved oxygen concentration, samples were taken at selected locations every hour during the first phase of the studies. In the second phase, samples were taken every hour to catch the maximum and minimum D. O. concentrations.

Whenever a sample was taken, time, temperature (to the nearest degree centigrade), and any descriptive remarks that would explain unusual conditions, were recorded on standard field sheets.

Presentation of Data

Water Quality - Nine hundred and seventy-five chemical determinations were made on 156 samples taken between Sand Springs and Webbers Falls; 88 coliform bacteria determinations were made on samples taken in this area. A summary of the analytical results is presented in Table B-3. Maximum, minimum and mean values are presented for dissolved oxygen, 5-day BOD at 20°C., temperature, per cent saturation, nitrate as N, phosphate (PO_4), chloride (Cl^-), turbidity, color and total alkalinity. In the case of the coliform M.P.N. data, a median value is used instead of a mean. A complete tabulation of all the results is presented in Table B-4 of the appendix.

A graphical representation of the dissolved oxygen and BOD results is presented in figure B-3. Figure B-4 shows the data obtained of the coliform M.P.N. values for the various sampling stations during this study.

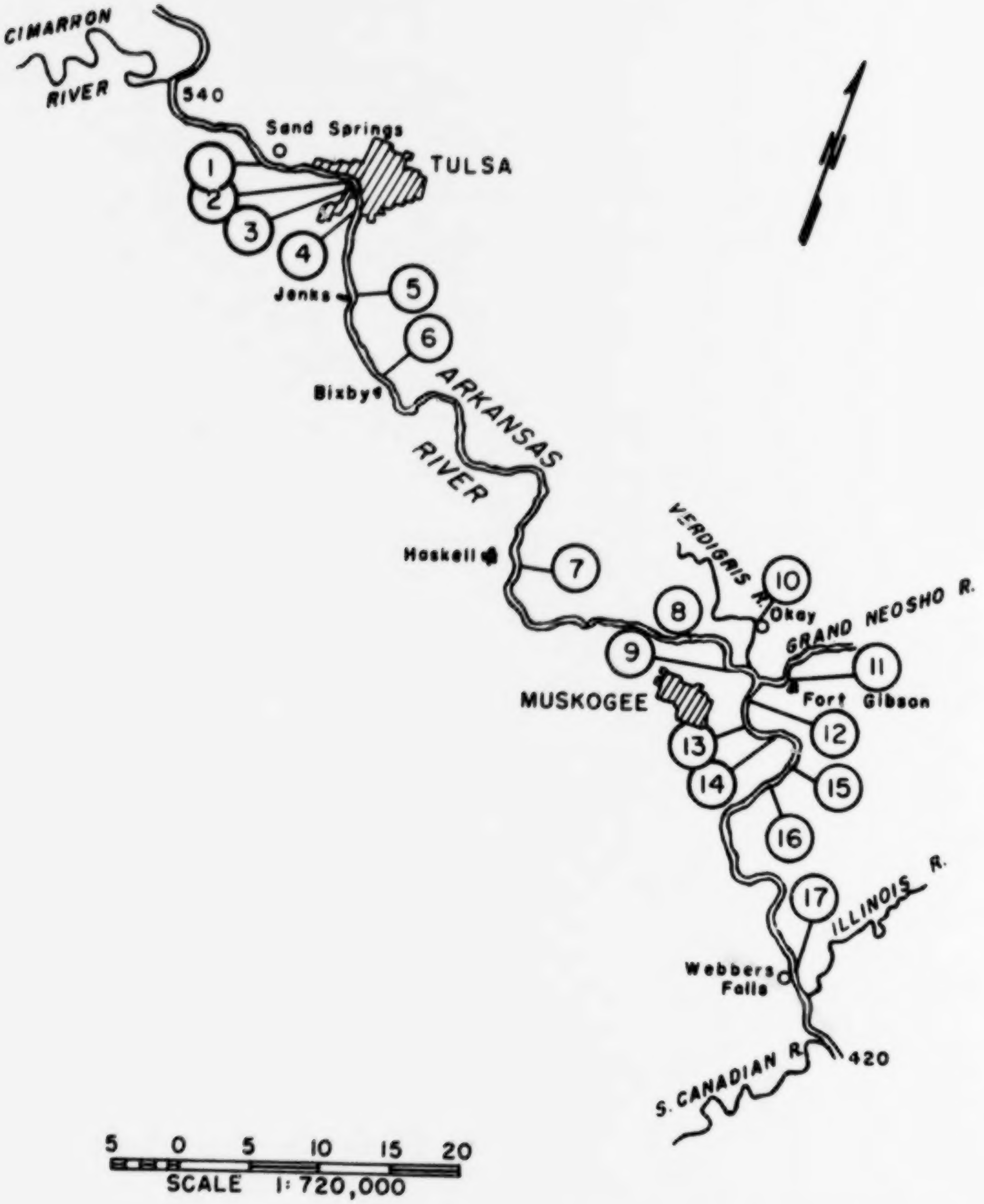
Table B-1 - Domestic Sources of Pollution - Arkansas River, Sand Springs, Okla., to Weber Falls, Okla.

Watercourse and Municipality	River Mile	Estimated Population Served by Sewers	Treatment	Estimated Population Equivalent Discharged to Watercourse
Arkansas R.				
Tulsa		50,000	None	50,000
		45,000	Secondary	15,000
Polecat Cr.	513.6			
Rock Cr.				
Sapulpa		9,800	None	9,800
Unnamed Trib.				
Kiefer		200	Primary	150
Jenks	514.9	800	None	800
Bixby	507.6	1,200	None	1,200
Duck Cr.				
Mounds		500	Primary	350
Snake Cr.				
Haikey Cr.				
Broken Arrow #1		1,200	Secondary	600
Broken Arrow #2		1,500	Secondary	750
Coweta Cr.				
Coweta		1,350	None	1,350
Coal Cr.				
Haskell		1,300	Primary	1,000
Cane Cr.				
Cloud Cr.				
Boynton		700	Primary	600
Muskogee #1	461.75	8,000	None	8,000
Verdigris R.	460.2			
Grand R.	459.5			
Muskogee #2		27,000	None	27,000
Weber Falls				

Table B-2 - Sampling Stations, Arkansas River, Sand Springs, Okla., to Weber Falls, Okla.

Sampling Station	River Mile	Description	Number of Days Sampled
1	A-530	U. S. 64 Highway Bridge at Sand Springs, Okla.	5
2	A-523.9	U. S. 66 Highway Bridge at Tulsa, Okla.	1
3	A-522.8	U. S. 169 Highway Bridge at Tulsa, Okla.	1
4	A-519.9	51st St. Bridge at Tulsa, Okla.	5
5	A-514.9	Okla. 11 Highway Bridge at Jenks, Okla.	6
6	A-507.6	U. S. 64 Highway Bridge at Bixby, Okla.	6
7	A-483.8	Highway Bridge at Haskell, Okla.	7
8	A-466.2	New U. S. 69 Highway Bridge at Muskogee, Okla.	9*
9	A-461.7	Old U. S. 69 Highway Bridge at Muskogee, Okla.	9
10	A-460.2, V-3.7	Old U. S. 69 Bridge over Verdigris R. at Okay, Okla.	7
11	A-459.5, G-2.6	Highway Bridge over Grand R. at Fort Gibson, Okla.	7
12	A-457.8	U. S. 62 Highway Bridge at Muskogee, Okla.	11
13	A-455.7	1/4 mile above South sewage outfall of Muskogee, Okla.	3
14	A-453.7	1.8 miles below South sewage outfall of Muskogee, Okla.	3
15	A-450.5	5 miles below South sewage outfall of Muskogee, Okla.	3
16	A-447.5	Smith's Ferry	3
17	A-428.4	U. S. 64 Highway Bridge at Weber Falls, Okla.	7*

* Does not include D.O. - algae study.


CIMARRON RIVER
540
Sand Springs
TULSA
1
2
3
4
Jenks
5
6
Bixby
ARKANSAS RIVER
Haskell
7
VERDIGRIS R.
10
Okay
8
9
GRAND NEOSHO R.
11
Fort Gibson
MUSKOGEE
12
13
14
15
16
17
ILLINOIS R.
Webbers Falls
S. CANADIAN R.
420
N
5 0 5 10 15 20
SCALE 1:720,000

SAMPLING STATIONS
ARKANSAS RIVER & TRIBUTARIES
SAND SPRINGS, OKLA. TO
WEBBERS FALLS, OKLA.
FIGURE NO. B-2

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 1 of 3)

Table B-3 - Summary of Individual Results, Sanitary Analysis, Arkansas River, mile 530 to mile 428.4

Station	Samples	Flow, cfs at Tulsa, Okla.	B.O.D. 5-day 20°C, ppm	D.O., ppm	Temperature, °C	Per Cent Saturation	Coliforms MPN per 100 ml	Nitrates as N, ppm	PO_4^{---} ppm	Chlorides Cl^- ppm	Turbidity ppm	Color, ppm	pH	Total Alkalinity, ppm
Mile 530	Number	5	5	5	5		5	5	5	5	5	5	5	5
Sand Springs	Mean	372	5.1	8.9	20	99	* 4,300	0.16		1,420	60	18		146
	Maximum	410	6.3	9.4	24	110	7,500	.20	0.004	1,660	67	20	8.2	154
	Minimum	362	3.8	8.4	15	84	4,300	.10	< .002	1,350	53	15	7.7	142
Mile 523.9	Number	1	1	1	1		1	1	1	1	1	1	1	1
Hwy Bridge U.S. 66	Value	410	3.96	9.41	20	105	93,000	.12	< .002	1,617	60	25	8.1	152
Mile 522.8	Number	1	1	1	1		1	1	1	1	1	1	1	1
Hwy. Br. U.S. 169	Value	410	4.43	10.20	22	118	93,000	.25	< .002	1,641	55	25	8.4	149
Mile 519.9	Number	5	5	5	5		5	5	5	5	5	5	5	5
51st St. Br. at Tulsa	Mean	362	10.8	6.0	20	67	* 930,000	.17	.176	1,330	48	24		152
	Maximum	362	20.0	9.5	25	120	4,300,000	.25	.240	1,340	54	25	7.9	159
	Minimum	362	7.3	3.4	14	34	430,000	.10	.080	1,310	38	20	7.5	147
Mile 514.9	Number	6	6	6	6		6	6	6	6	6	6	6	6
Hwy. Br. at Jenks	Mean	370	7.8	8.5	21	99	* 980,000	.19	.307	1,360	42	25		157
	Maximum	410	15.0	12.8	26	159	2,400,000	.27	.500	1,510	54	30	8.3	167
	Minimum	362	5.6	6.1	14	66	150,000	.09	.130	1,300	30	20	7.5	144
Mile 507.6	Number	6	6	6	6		6	6	6	6	6	6	6	6
Hwy. Br. at Bixby	Mean	370	5.5	9.2	21	105	* 930,000	.21	.378	1,310	36	26		157
	Maximum	410	6.2	14.0	26	173	2,400,000	.30	.560	1,390	47	30	8.4	169
	Minimum	362	3.7	6.7	13	73	150,000	.12	.240	1,280	30	25	7.7	148

* Median

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 2 of 3)

Table B-3 - Summary of Individual Results, Sanitary Analysis, Arkansas River, mile 530 to mile 428.4 (Continnued)

Station	Samples	Flow, cfs at Tulsa, Okla.	B.O.D. 5-day 20°C, ppm	D.O., ppm	Temperature, °C	Per Cent Saturation	Coliforms MPN per 100 ml	Nitrates as N, ppm	PO_4^{---} ppm	Chlorides Cl^- ppm	Turbidity ppm	Color, ppm	pH	Total Alkalinity, ppm
Mile 483.8 Hwy Br at Haskell	Number	7	7	7	7		7	7	7	7	7	7	7	7
	Mean	381	6.6	11.4	20	126	* 93,000	0.15	0.010	1,260	55	25		129
	Maximum	422	9.5	14.2	25	157	1,100,000	.20	.040	1,370	64	25	8.5	148
	Minimum	362	5.4	9.7	18	100	24,000	.11	.002	1,210	33	25	7.9	112
Mile 466.2 New 69 Br. at Muskogee	Number	11	10	10	10		8	8	8	11	10	11	11	11
	Mean	378	7.0	11.3	20	125	* 9,300	.18		1,220	65	24		124
	Maximum	422	8.8	14.0	24	166	24,000	.28	.006	1,280	80	30	8.7	154
	Minimum	362	5.9	9.0	14	98	1,400	.05	< .002	1,180	44	15	7.6	104
Mile 461.7	Number	11	10	10	10		8	8	8	11	10	11	11	11
	Mean	378	8.1	10.4	20	113	* 92,000	.17		1,210	73	24		123
	Maximum	422	12.0	12.9	25	157	4,600,000	.27	.006	1,300	90	30	8.7	154
	Minimum	362	5.5	7.8	14	88	23,000	.06	< .002	1,150	47	15	7.7	104
Verdigris River Old U.S. 69 bridge	Number	9(1)	8	8	8		7	7	7	9	8	9	9	9
	Mean	52	1.8	8.0	22	91	* 350	.12		323	32	10		159
	Maximum	64	2.5	9.4	25	110	1,200	.17	.010	348	37	10	8.4	169
	Minimum	46	1.0	5.9	15	65	150	.08	< .002	306	26	10	7.6	143
Grand River at Fort Gibson	Number	9(2)	8	8	8		7	7	7	9	8	9	9	9
	Mean	1,585	0.9	8.5	22	94	* 230	.31	.007	14		6		120
	Maximum	2,530	1.4	9.0	23	100	2,400	.35	.020	16	48	10	8.0	123
	Minimum	714	.6	8.1	15	87	91	.27	.002	13	<25	5	7.7	115

(1) Flow measured at Inola, Okla.
(2) Flow measured at Ft. Gibson, Okla.

* Median

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 3 of 3)

Table B-3 - Summary of Individual Results, Sanitary Analysis, Arkansas River, mile 530 to mile 428.4 (Continued)

Station	Samples	Flow, cfs at Muskogee, Okla.	B.O.D. 5-day 20°C, ppm	D.O., ppm	Temperature, °C	Per Cent Saturation	Coliforms MPN per 100 ml	Nitrates as N, ppm	PO_4^{---} ppm	Chlorides Cl^- ppm	Turbidity ppm	Color, ppm	pH	Total Alkalinity, ppm
Mile 457.8	Number	13	12	12	12		9	9	9	13	12	13	13	13
	Mean	2,111	2.7	9.2	19	98	* 4,300	0.22		306	38	12		124
	Maximum	3,190	4.4	10.2	23	117	43,000	.32	0.008	432	55	15	8.1	132
	Minimum	1,320	1.7	8.1	14	90	910	.13	< .002	109	31	10	7.6	116
Mile 455.7	Number	3	1	3	3		2							
	Mean	2,313	4.1	8.5	19	91								
	Maximum	2,980		9.4	23	93	9,300							
	Minimum	1,480		8.0	14	90	4,300							
Mile 453.7	Number	3	1	3	3		2							
	Mean	2,313	2.8	9.1	19	97								
	Maximum	2,980		10.2	22	100	23,000							
	Minimum	1,480		8.0	14	91	43,000							
Mile 450.5	Number	3	1	3	3		2							
	Mean	2,313	3.4	9.5	19	101								
	Maximum	2,980		10.3	22	110	43,000							
	Minimum	1,480		8.4	14	94	9,300							
Mile 447.5	Number	3	3	3	3		2	2	2	3	2	2	3	3
	Mean	2,313	4.1	9.9	20	108		0.16	0.003	329	42	18		127
	Maximum	2,980	4.8	11.0	22	114	240,000	.27	.004	381	53	20	8.4	133
	Minimum	1,480	3.4	8.7	16	99	93,000	.06	.002	243	31	15	7.9	124
Mile 428.4	Number	8	8	8	8		5	5	5	8	8	8	8	8
	Mean	2,058	3.3	10.4	18	108	* 2,400	0.19		332	44	14		126
	Maximum	3,190	6.5	11.1	24	121	4,300	.24	.008	379	61	15	8.7	134
	Minimum	1,420	2.4	9.2	12	91	230	.13	< .002	199	35	10	8.1	116

* Median

Table B-10 - Bottom Organisms, Arkansas River,
Sand Springs-Muskogee, Oklahoma, Areas
(Collected October 7-8-9, 1952)

(Sheet 1 of 3)

Station	Insects	Mollusca	Annelida	Remarks
Mile 531.5 above Sand Springs	Diptera Chironomidae, few Family(?), one Odonata Dragonfly, few		Few	Soft bottom
Mile 515 at Jenks	(Heavy oil deposits present on the bottom)	Snails (Physa), numerous		Sandy and rocky bottom - green algae abundant, Scenedesmus, Microspora, diatoms, Bryozoa, abundant
Mile 483.8 near Haskell	Diptera Chironomidae, very numerous Muscidae, one (Some oil deposits present on the bottom)		Numerous	Sandy bottom - filamentous green algae abundant
Mile 463 above Muskogee north outfall	Ephimerida, numerous Diptera Chironomidae, very numerous Trichoptera, very numerous Odonata Damsel fly, few			Rocky bottom, rapid flow-Bryozoa abundant, green algae: Scenedesmus, Selenastrum. Diatoms: Stauroneis, Synedra, Closterium
Mile 461.5 at Muskogee below north outfall	Trichoptera, very numerous Diptera Chironomidae, numerous Neuroptera (Corydalis), few Odonata Dragonfly, few			Sand and rock

Table B-10 (Continued)

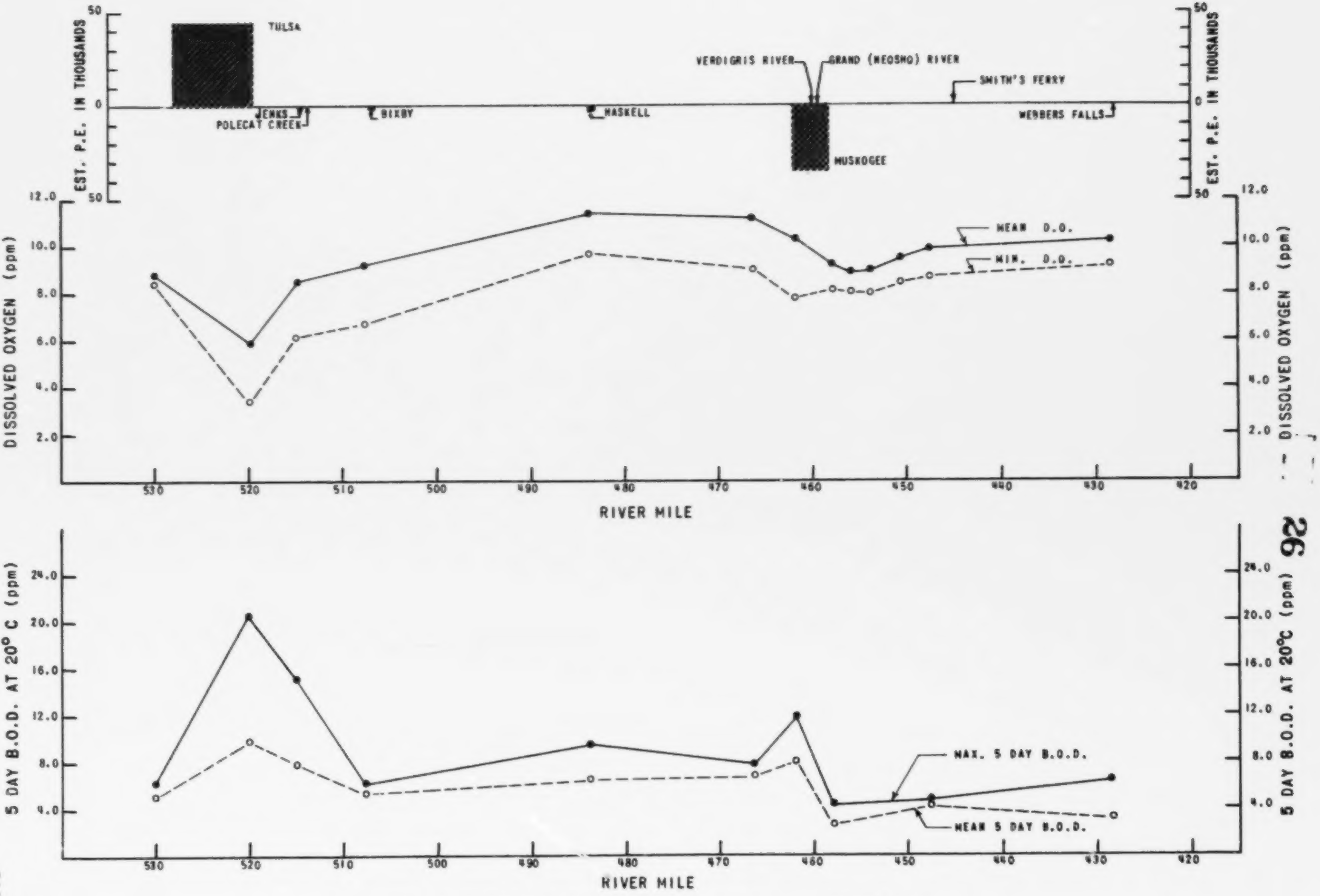
(Sheet 2 of 3)

Station	Insects	Mollusca	Annelida	Remarks
Mile 455.5 at Muskogee 1/4 mi.above south outfall	Odonata Dragon flies, numerous Damsel flies, numerous Neuroptera (Corydalis), few Trichoptera, very numerous Diptera Chironomids, very numerous Coleoptera Coripidae, numerous Ephimerida, few	Snails (Physa), numerous	Numerous	Rocky, sandy - Bryozoa abundant
Mile 453.5 at Muskogee, 2 mi. below south outfall	Diptera Chironomidae, very numerous Trichoptera very numerous Ephimerida, few Neuroptera (Corydalis), very numerous Odonata Dragonfly, very numerous Damsel fly numerous		Few	Rocky bottom, swift current - Bryozoa abundant. Green algae (Cladophora) profuse
Mile 447.5 at Smith's Landing	Trichoptera very numerous Diptera Chironomidae, numerous Odonata Dragonfly, few Damsel fly, few Ephimerida numerous			Rock and sand - Bryozoa abundant. Diatoms abundant. Green algae, Cladophora, abundant. Scenedesmus

Table B-10 (Continued)

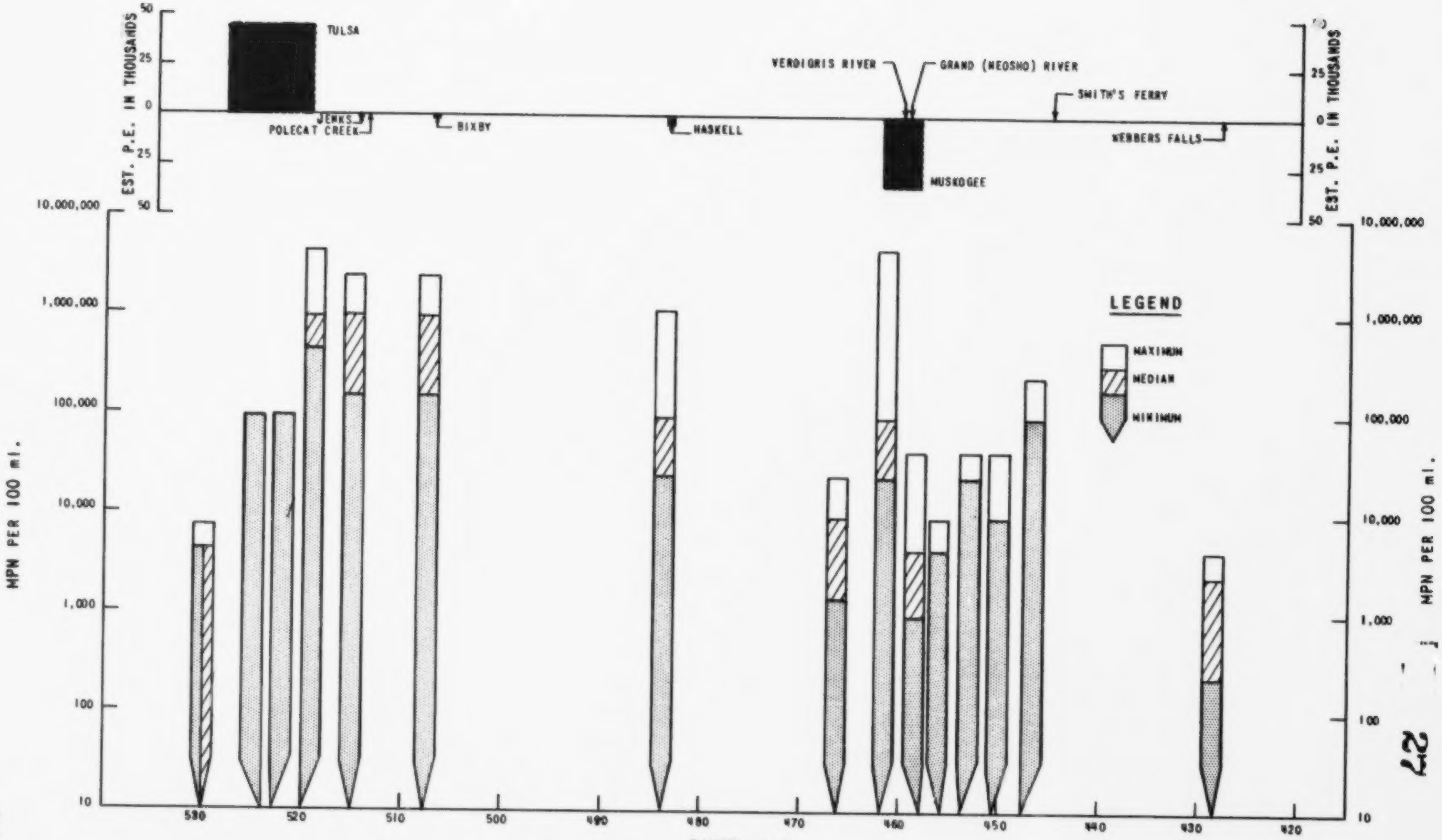
(Sheet 3 of 3)

Station	Insects	Mollusca	Annelida	Remarks
Mile 428.4 at Webbers Falls	Ephimerida numerous Diptera Chironomidae, numerous Trichoptera, few Odonata, scarce			Sandy, few rocks, swift current - Cladophora abundant
Grand River 2 miles above mouth	Odonata Dragonfly, few Damsel fly numerous Trichoptera very numerous Diptera Chironomidae, very numerous Neuroptera (Corydalis), few Coleoptera Naucoridae, few	Clams, few		Rocky bottom - Green algae, Cladophora, abundant
Verdigris River 4 miles above mouth	Neuroptera (Corydalis), numerous Trichoptera very numerous (Very great concentration of organisms)			Rock bottom- Bryozoa very abundant



DISSOLVED OXYGEN AND 5 DAY B.O.D. AT 20° C vs. RIVER MILE
ARKANSAS RIVER
(SEPTEMBER 22, 1952 TO OCTOBER 10, 1952)

FIGURE B-3



COLIFORM MPN/100 ml vs. RIVER MILE
ARKANSAS RIVER
(SEPTEMBER 22, 1952 TO OCTOBER 10, 1952)

FIGURE B-4

Special Studies - Effect of algae on the concentration of dissolved oxygen. The results of these studies are shown graphically, on a dissolved oxygen ppm and per cent saturation basis for both sampling points in Figures B-5 and B-6. The data for these studies are presented in Table B-5 in the appendix. Figure B-7 is a plot for all stations of the dissolved oxygen as per cent saturation observed in the course of regular sampling versus daily sampling time. The mean nitrate as N and phosphate (PO_4) concentrations are also plotted by stations.

Hydrological Data - The flow data at the various sampling points for the days sampled are summarized in Table B-3, and presented in their entirety in Table B-4 in the appendix. Figure B-8 shows the flows occurring at various stations in the area during the survey. The data are presented in Tables B-6, B-7, B-8 and B-9 in the appendix. Analyses of past flow data at Tulsa, Okla. (1938-1950) and at Muskogee, Okla. (1935-1950) have been made. The results of these analyses are presented in Figures B-9 and B-10. A comparison of the flows in the Grand (Neosho) River and in the Arkansas River is shown in Table B-12.

Temperature Data - Figure B-11 is a frequency distribution plot of water temperature at Tulsa, Okla. The analysis was made of water temperature data available during June, July, August, September and October for the water years October 1946 to September 1950.

Biological - The data obtained during the biological phase of this survey are presented in Table B-10.

Discussion

Water Quality

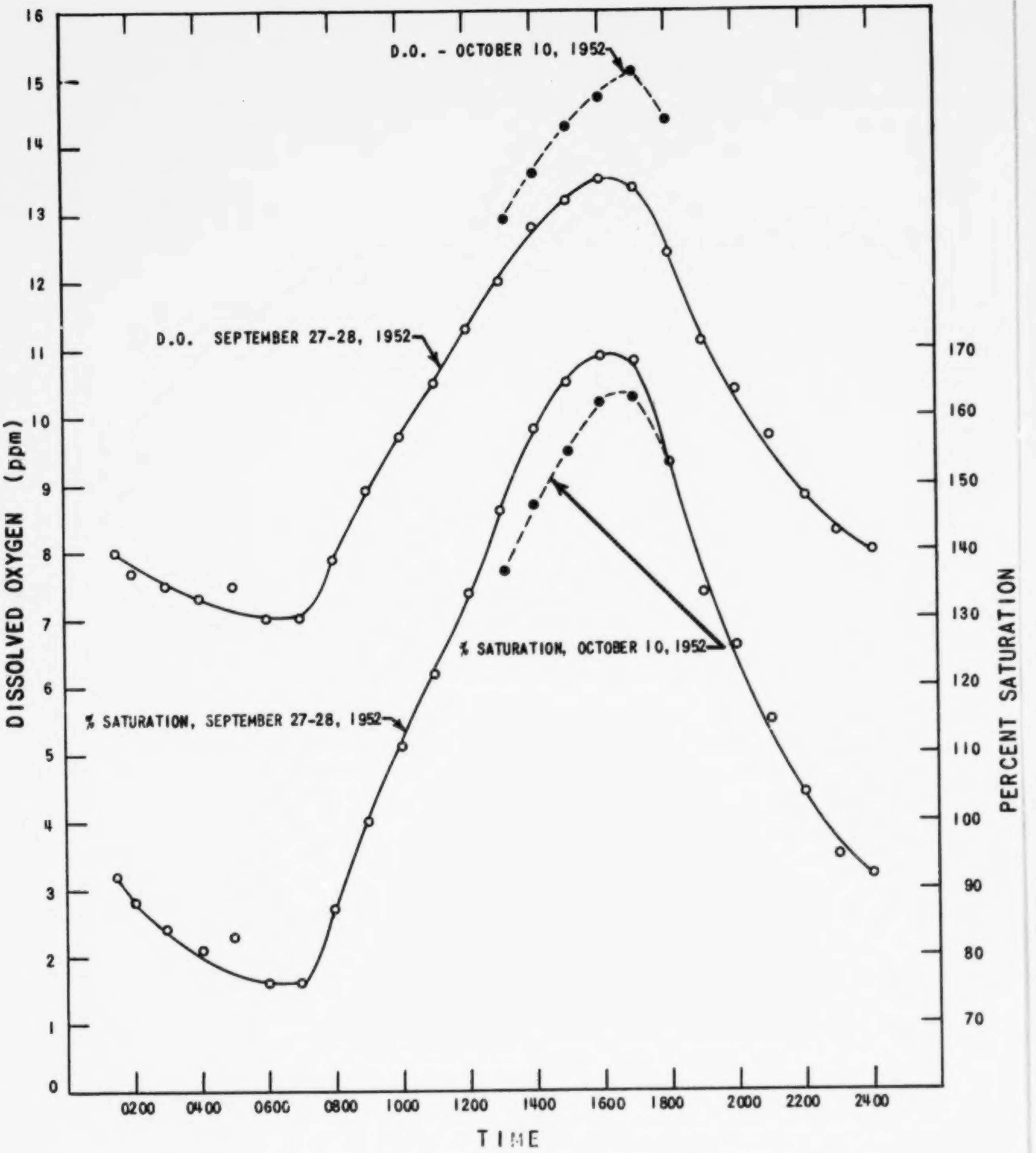
Dissolved Oxygen - Due to the existence of high algae activity in certain stretches of the river in this area, a discussion is initially presented on the effect of algae on oxygen concentrations, before the observed results are discussed.

Increase of Dissolved Oxygen in the Arkansas River due to Algae Activity- The data show that supersaturated dissolved oxygen conditions existed in the Arkansas River in this stretch between Sand Springs and Webbers Falls. To determine the extent of algae activity in terms of dissolved oxygen, two sampling points were picked, one at mile 466.2 (the new U.S. 69 highway bridge at Muskogee) and the other at mile 428.4 (the highway bridge at Webbers Falls).

At mile 466.2, on September 27 to 28, 1952, dissolved oxygen samples were taken hourly. Figure B-5 shows the dissolved oxygen reached a low of 7.0 ppm (76% of saturation) at 0600 and reached its maximum of 13.5 ppm (169% of saturation) at 1600. Dissolved oxygen samples were taken on October 10, 1952, to determine the maximum dissolved oxygen concentration of that day. The maximum dissolved oxygen concentration of 15.1 ppm (163% of saturation) occurred approximately at hour 1655. The increase in the maximum dissolved oxygen value for October 10 compared to that occurring on September 26, 1952, can be attributed to the lower water temperatures occurring on the 10th (See Table B-5 in Appendix).

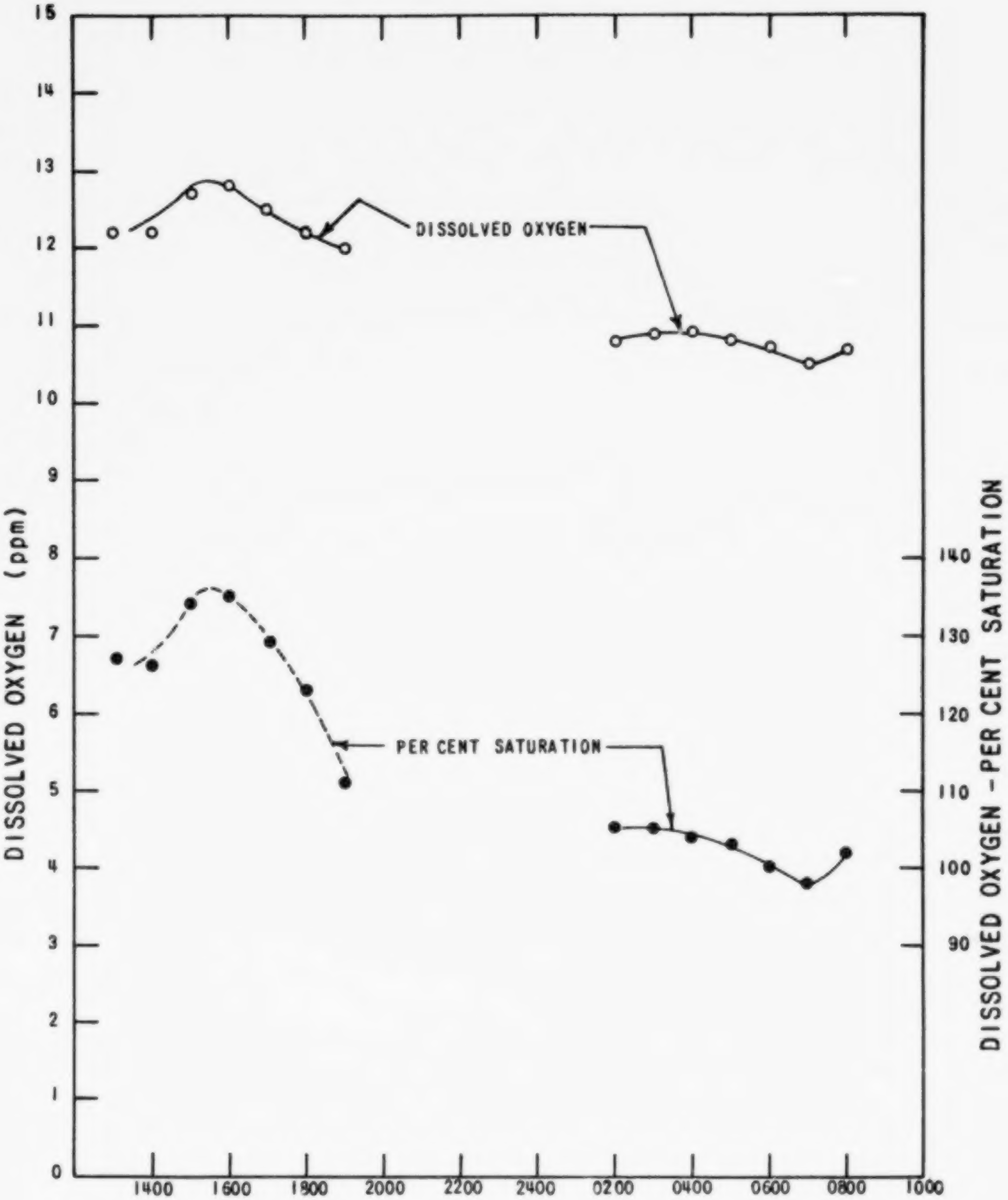
At Webbers Falls (mile 428.4) samples were taken to determine the maximum and minimum dissolved oxygen concentrations on October 10 and 11. The maximum dissolved oxygen of 12.8 ppm (135% of saturation) occurred at 1600 (See Figure B-6 and Table B-5). The minimum, 10.5 ppm (98% of saturation), occurred on the 11th at 0700.

On the basis of results found in this special study, an analysis was made of all the dissolved oxygen data acquired by regular sampling procedures. The



DISSOLVED OXYGEN AND PERCENT SATURATION vs. TIME
ARKANSAS RIVER (MILE 466.2)

FIGURE B-5



DISSOLVED OXYGEN AND PERCENT SATURATION vs. TIME
ARKANSAS RIVER (MILE 428.4)

FIGURE B-6

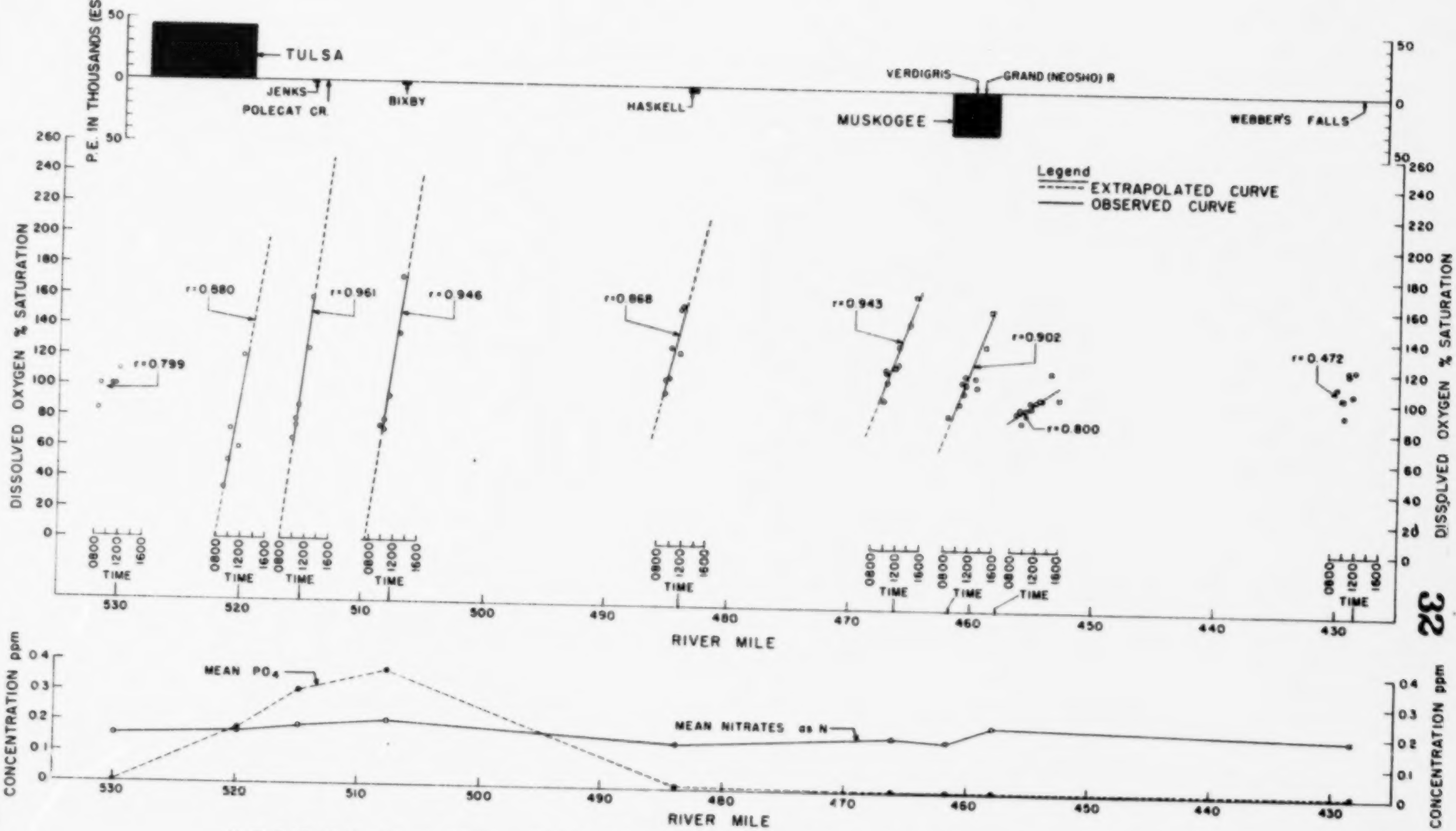


FIGURE B-7

D.O. SATURATION vs. TIME vs. RIVER MILE AND NITRATES AND PHOSPHATES vs. RIVER MILE

ARKANSAS RIVER

(SEPT. 22 TO OCT. 10, 1952)

results of this analysis are presented in Figure B-7 (Also plotted in this figure are the mean nitrate as N and the mean phosphate (PO_4) concentrations found during this survey). The dissolved oxygen values in per cent of saturation were plotted against sampling time. A regression line was fitted by the method of least squares, and correlation coefficients were calculated for each plot (coefficients are shown in Figure B-7). The data obtained at Sand Springs and Webbers Falls showed poor correlation; therefore no regression line was fitted. Figure B-5 shows that the algae photosynthesis process occurred between 0600 and 1655 at mile 466.2. The flow conditions at this station during the survey were representative of the conditions existing from Sand Springs (mile 530) to above the confluence of the Verdigris, Grand (Neosho) and Arkansas Rivers (between miles 459 and 461). On this basis, the regression lines shown in Figure B-7 have been extended (dotted lines) to cover the period from 0700 to 1600 hours (daylight hours).

From these extensions of the regression lines, particularly the portions down to 0700 hours, it can be hypothesized that the minimum dissolved oxygen values observed during the survey were not the true minimum concentrations that would have been observed if samples had been obtained when the photosynthesis process was not occurring. If anything, these plots might be extended to lower dissolved oxygen saturation values. If the hypothesis is true, then the dissolved oxygen in the stream at mile 519.9, 514.9 and 507.6 decreased to zero during the early morning hours.

The slope of these regression lines is a measure of the activity of the algae at each location. The sharp decrease in the slope of the regression lines in the section, mile 461.7 to mile 457.8, is attributed to the mixing of the Grand (Neosho) and Verdigris Rivers with the Arkansas River.

It is necessary to consider the effect of algae activity when evaluating the oxygen data presented in this report.

Observed Dissolved Oxygen Concentrations - The observed dissolved oxygen concentrations, as found by regular sampling methods, present a considerably higher minimum concentration than would be the case if the algae activity was taken into account. Table B-11 presents a comparison of the mean and minimum dissolved oxygen concentration as observed by routine sampling procedures to those values expected due to algae activity. The dissolved oxygen data in the Tulsa area lends itself to an analysis based on the Streeter-Phelps oxygen sag equation. On the basis of the observed dissolved oxygen data and adjusting these data to account for algae activity observed in the stream, an analysis was made based on this equation. The following are the results of these analyses. It was assumed that a 4.00 ppm dissolved oxygen concentration should be maintained in the stream at a daily average water temperature of 25°C.

a. Present Population

1. Degree of treatment (reduction in BOD) needed at 25° and 362 cfs	50%
2. Flow necessary for pollution abatement by dilution	1000 cfs
3. Flow necessary for pollution abatement by dilution, assuming primary treatment of Tulsa's wastes	700 cfs

TABLE B-11 ARKANSAS RIVER - COMPARISON OF DISSOLVED OXYGEN CONCENTRATIONS AS OBSERVED BY ROUTINE SAMPLING AS COMPARED WITH EXPECTED CONCENTRATIONS DUE TO ALGAE ACTIVITY

	Dissolved Oxygen (Per Cent Saturation)			
Station	Observed by Routine Sampling		Expected Due to Algae Activity	
	Mean	Min.	Mean	Min.
Mile 530	99	84	105	84
Mile 519.9	67	34	90	0
Mile 514.9	99	66	108	0
Mile 507.6	105	73	110	0
Mile 483.8	126	100	143	71
Mile 466.2	125	98	122	75
Mile 461.7	113	88	112	64
Mile 457.8	98	90	97	84
Mile 455.7	91	90	-	-
Mile 453.7	97	91	-	-
Mile 450.5	101	94	-	-
Mile 447.5	108	99	-	-
Mile 428.4	108	91	115	92

Table B-12 - Comparison of Average Daily Flows of Arkansas and Grand (Neosho) Rivers, Sept. 22 - Oct. 9, 1952

Date	Average Daily Flow at Muskogee Gage Arkansas R. cfs	Average Daily Flow at Ft. Gibson Gage Grand (Neosho) R. cfs	$\frac{\text{Flow Grand}}{\text{Flow Arkansas}} \times 100$
Sept. 22, 1952	2770	1630	59
23	2140	1210	56
24	2480	1950	79
25	3190	2530	79
26	2980	2070	70
27	2480	1830	74
28	2480	1830	74
29	2480	1830	74
30	2480	1820	73
Oct. 1	2370	1510	64
2	1730	1100	64
3	1660	1040	63
4	1640	1030	63
5	1610	1030	64
6	1610	1002	62
7	1480	940	64
8	1420	875	62
Average	2176	1483	68

Flow data obtained from Corps of Engineers.

b. Population Increase of 25%

1. Degree of treatment needed (reduction in BOD) needed at 362 cfs and 25°C.	60%
2. Flow necessary for pollution abatement by dilution	1200 cfs
3. Flow necessary for pollution abatement by dilution, assuming primary treatment of Tulsa's wastes	800 cfs

Five Day BOD at 20°C. - Figure B-3 indicates two areas of abrupt increase of the 5-day BOD values in the stream. The greatest change occurs at Tulsa where the addition of domestic and industrial wastes from Tulsa increase the mean 5-day BOD in the stream from 5.1 ppm (as observed at Sand Springs) to 10.8 ppm. The river recovers in travelling 12.3 miles downstream from Tulsa to Bixby, to a level comparable with that observed at Sand Springs.

The second abrupt increase occurs below Muskogee's north outfall. The addition of sewage from this outfall (which includes wastes from a chicken processing plant) increases the mean 5-day BOD to 8.0 ppm below the outfall.

Two miles downstream from this point, the Verdigris and Grand (Neosho) Rivers (the latter contribution approximately 68% of the flow below the confluence during the survey) join the Arkansas River. This added dilution causes a sharp decrease in the mean 5-day BOD to 4.1 ppm above Muskogee's south outfall. The addition of sewage from this outfall causes a slight increase in the 5-day BOD of the stream.

Temperature - During the period of the survey the temperature varied from a high of 26°C. to a low of 14°C., averaging approximately 20°C.

Coliform Densities, MPN - Figure B-4 shows that there were three different stretches of river showing increased coliform densities. The first increase occurred below Tulsa where the addition of Tulsa's wastes increased the median coliform MPN/100 ml from 4,300 to 1,000,000. The second occurred below Muskogee's north outfall, where the coliform MPN/100 ml was increased from 9,300 to 100,000. The third and smallest increase occurred below Muskogee's south outfall.

Nitrate as N - The nitrate concentrations for the stretch of river surveyed presented in Figure B-7, varied from 0.06 to 0.32, averaging 0.1 ppm. These concentrations are of the magnitude that would be expected to support activity of most algae.

Phosphates (PO_4) - The concentration of phosphates at Sand Springs ranged from 0.002 to 0.004 ppm. As can be seen in Table B-3 and Figure B-7, there is a large increase in the phosphate concentration just below Tulsa, the average being 0.176 ppm. The phosphate concentration increases still more in the next 12.3 miles, and at Bixby the mean value is 0.378 ppm. At Haskell, 23.8 miles downstream, the concentration averages 0.01 ppm. There is a further decrease in phosphate concentrations immediately above Muskogee's north outfall, with the concentrations ranging from 0.002 to 0.006 ppm. These concentrations remain fairly constant downstream to Webbers Falls and are of the order of those at Sand Springs. Phosphates in the concentrations observed could stimulate the growth of some algae.

Chlorides (Cl^-) - The mean chloride concentration from Sand Springs to the station immediately above the confluence of the Grand (Neosho), Verdigris and Arkansas Rivers, averaged 1,290 ppm. Concentrations ranged from 1,420 ppm at Sand Springs to 1,220 ppm immediately above the junction of the three rivers.

Below the confluence of the Verdigris, Grand (Neosho) and Arkansas Rivers, the average chloride concentration for the period of survey was 306 ppm. This decrease is due to dilution from the mixing of two relatively chloride-free rivers with the Arkansas (see "Discussion of Hydrometric Data").

Turbidity - The turbidity of the Arkansas River between Sand Springs and Webbers Falls remained fairly constant during the survey. The mean values of the various stations ranged from 32 to 74 ppm.

Color - The summary of the data presented in Table B-3 shows that the average color of the Arkansas River increased from 18 ppm to 24 ppm in passage past Tulsa, Okla. This value remained fairly constant down to the confluence of the Verdigris, Grand (Neosho) and Arkansas Rivers, where the average color drops to 12 ppm. There is a slight increase due to the addition of the sewage from Muskogee's south outfall, as shown by the average color value of 18 ppm eight miles downstream from the outfall. At Webbers Falls the color averaged 14 ppm.

pH - The pH of the Arkansas River over the stretch investigated ranged between 7.5 and 8.7.

Total Alkalinity - From Sand Springs to Bixby, a distance of 22.4 river miles, the average total alkalinity ranged from 146 to 157 ppm. At Haskell (23.8 miles below Bixby), the alkalinity averaged 129 ppm. The alkalinity decreased to 118 ppm above the confluence of the three rivers, and remained fairly constant from that point to Webbers Falls, the average alkalinity ranging between 122 to 127 ppm.

Special Studies

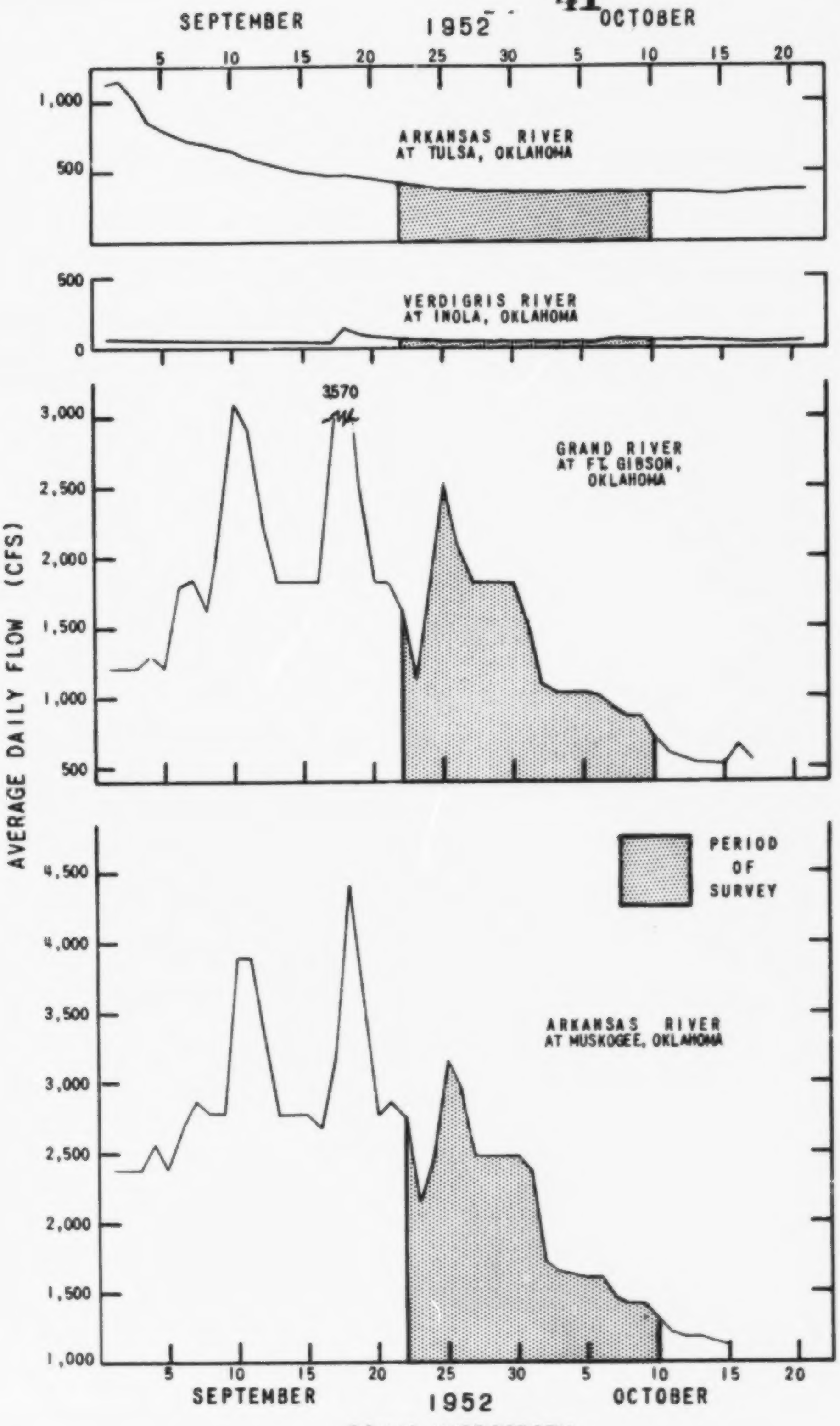
Dispersion of Tulsa's Sewage in the Arkansas River - The river in this area occupied approximately only 10 per cent of its normal bed, the greatest depth being approximately 2 1/2 feet. Under these conditions it was observed that thorough dispersion of the sewage in the river was completed in a very short distance. Two samples were taken, one at a 6-inch depth, the other at a 2-foot depth. The dissolved oxygen was 7.2 ppm and 7.3 ppm, and corroborates the visual observations.

The dispersion pattern observed during this survey should not be changed during similar low flow periods by the construction of the proposed dam at Webbers Falls.

Dispersion of Muskogee's Sewage in the Arkansas River - The river conditions around the north outfall of Muskogee were almost identical to those observed at Tulsa. The samples taken above and below the outfall bore out the observation that rapid mixing was taking place within approximately 200 yards distance, as shown by data in Table B-4 in the Appendix; on two separate runs, the top and bottom dissolved oxygens and BOD's were the same.

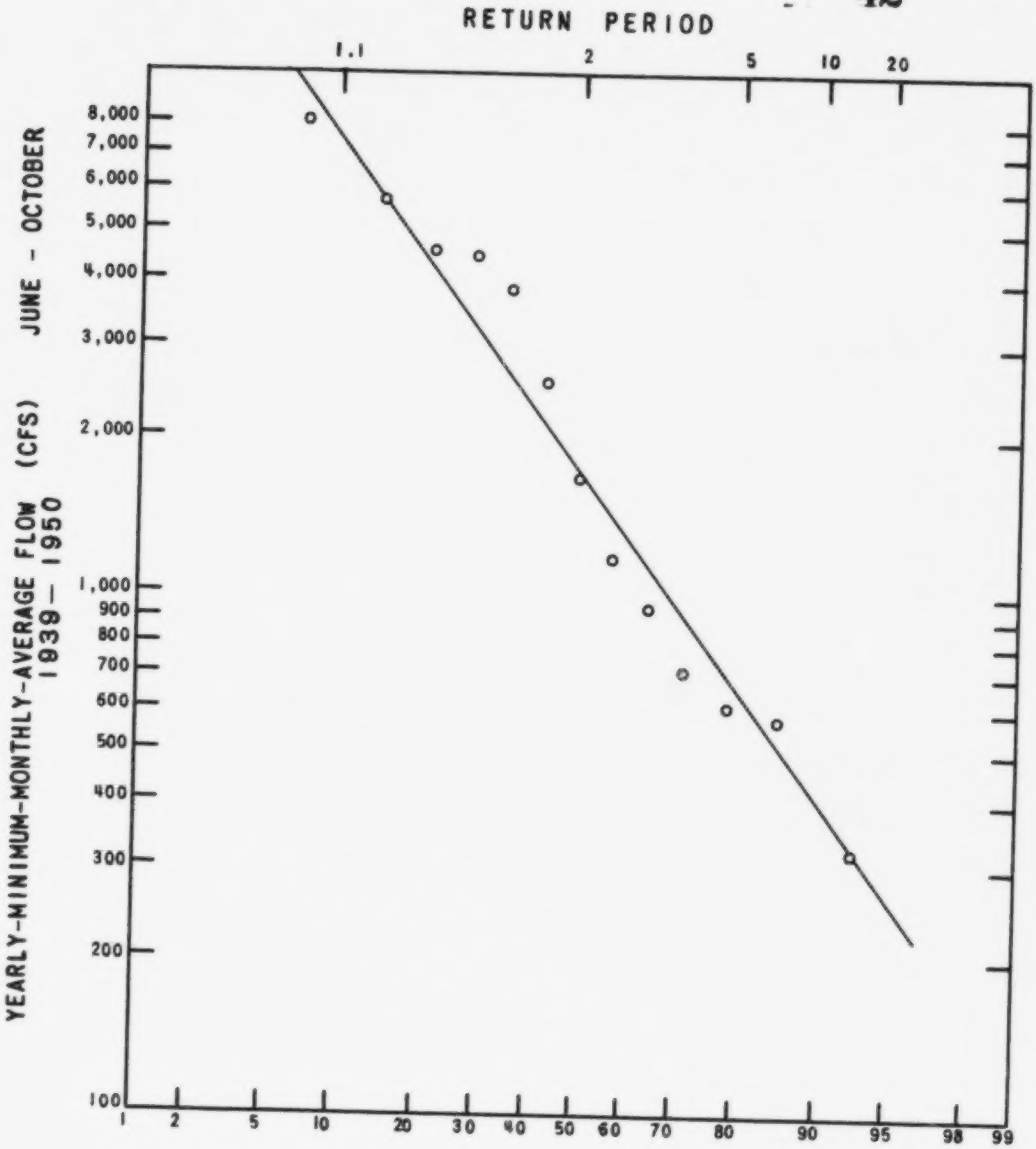
Immediately below Muskogee's south outfall, there existed at the time of the survey a shoal area extending approximately 3/4 of a mile downstream. Between the outfall and this shoal area, a sludge bank approximately 100 yards in length and 50 yards in width was present. It was caused by the eddying of the water behind the outfall. The outfall was above the water surface on concrete pilings projecting out into the stream. It was observed that thorough mixing of the sewage with the river occurred in passage over the downstream shoal area. Data from Table B-4 in the appendix corroborate the visual observations.

The proposed installation of locks and dams on the Arkansas and Verdigris Rivers will maintain a channel depth of 9 feet. It is probable that the dispersion of Muskogee sewage observed during this survey at low flow conditions



DAILY HYDROGRAPH
ARKANSAS RIVER (AT TULSA AND MUSKOGEE, OKLAHOMA)
VERDIGRIS RIVER AND GRAND RIVER

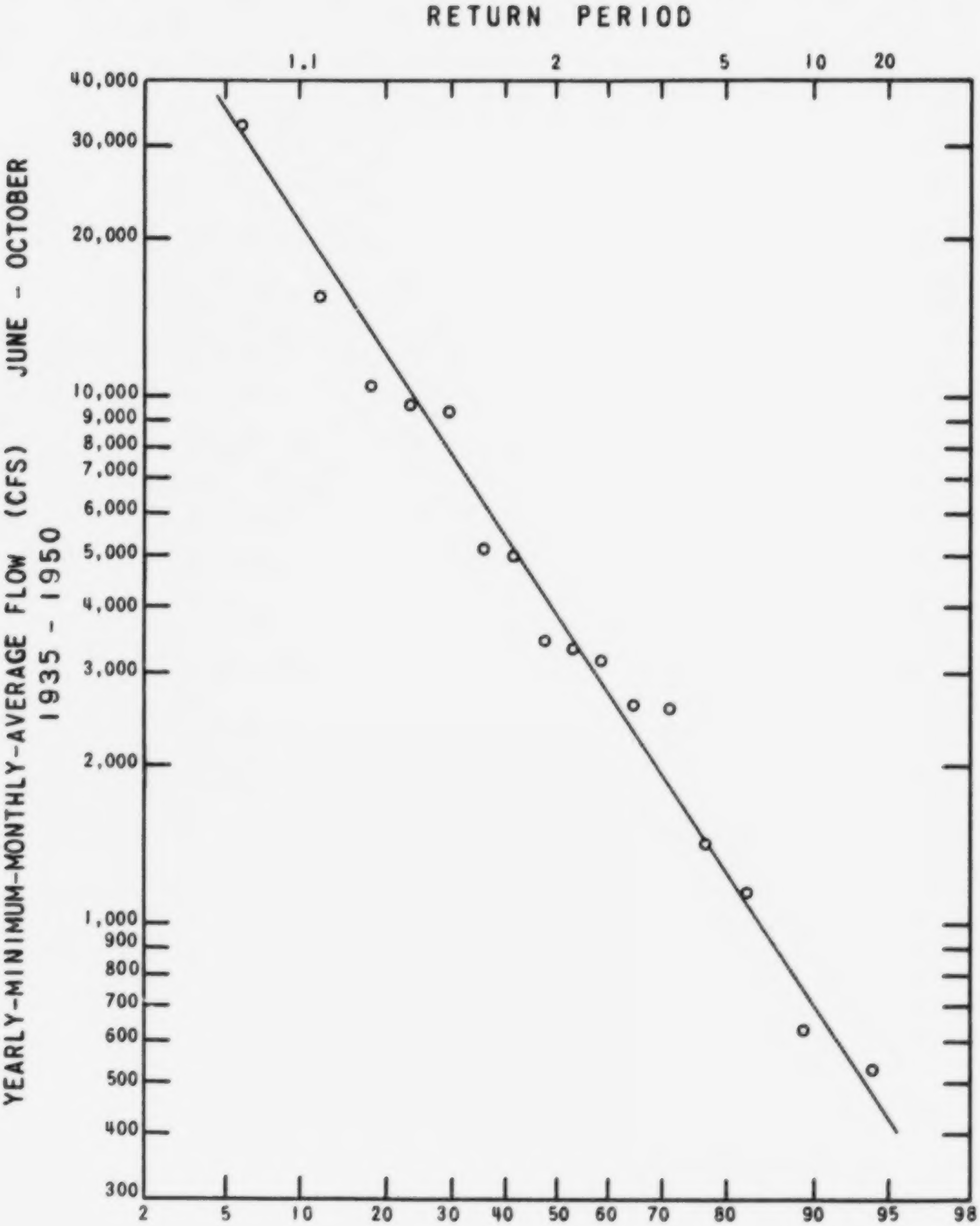
FIGURE B-8



PERCENT OF YEARS, YEARLY-MINIMUM-MONTHLY-AVERAGE FLOW, (JUNE - OCTOBER) ≥ INDICATED FLOW

FLOW FREQUENCY DISTRIBUTION
ARKANSAS RIVER
TULSA, OKLAHOMA

FIGURE B-9



PERCENT OF YEARS, YEARLY-MINIMUM-MONTHLY-AVERAGE FLOW, (JUNE - OCTOBER) ≧ INDICATED FLOW

FLOW FREQUENCY DISTRIBUTION

ARKANSAS RIVER

MUSKOGEE, OKLAHOMA

FIGURE B-10

will not be the same for similar low flow periods after installation of the locks and dams.

Hydrologic Data - Hydrographs for the Arkansas River at Tulsa and Muskogee, Oklahoma, the Verdigris River at Inola, Oklahoma, and the Grand (Neosho) River at Ft.Gibson, Oklahoma, as shown in Figure B-8, are plots of the data contained in Tables B-6, B-7 and B-9. An examination of the hydrographs for the Grand River, and the Arkansas River at Muskogee, show that the plots of the flows for similar periods are parallel to each other. This would indicate that, during low-flow conditions, the flow below Muskogee is governed by the flow of the Grand (Neosho) River. This is shown in Table B-12, which is a comparison of the flow in the Grand (Neosho) and the Arkansas Rivers, during the days of sampling. During this period of time, the flow in the Grand (Neosho) River averaged 68% of the flow in the Arkansas River at Muskogee; the flow in the Grand (Neosho) River is controlled by the reservoir at Ft.Gibson. About Sept. 30, the flow in the Grand River was decreased to allow for increasing the water level behind the Ft.Gibson dam. Therefore, the flow on the 8th of October was slightly greater than 50 per cent of the flow on the 30th of September.

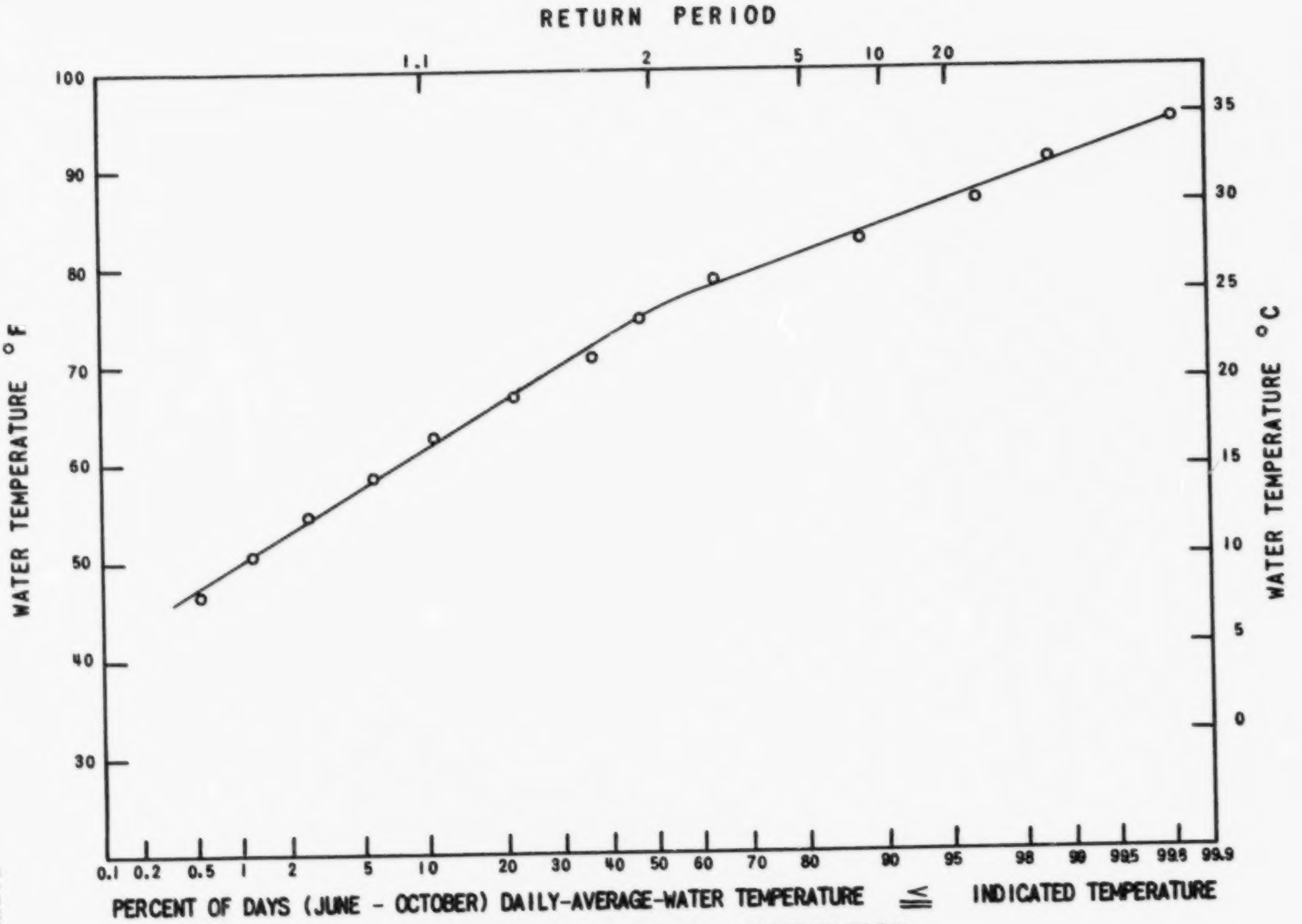
Analyses were made of past flow records of the Arkansas River at Tulsa and Muskogee, Okla. The monthly average flows for June, July, August, September and October of each year were tabulated, and the minimum monthly average flow for each year was used in the analysis. At Tulsa, a continuous record was available from 1936 to 1950. The records at Muskogee cover the period 1935 to 1950. Graphs B-9 and B-10 are the plots of these analyses. At Tulsa, the flow averaged 373 cfs for the period of the survey. If such a flow could be considered as an average monthly flow, it would have a return period of approximately once every ten years, i.e. once every ten years the average monthly flow in a year would be equal to or less than this flow.

At Muskogee, for the period of the survey, the Arkansas River averaged 2,176 cfs. From Graph B-10 it can be seen that this flow, if it is considered a monthly average flow, would have a return period of approximately once every three years. The flow corresponding to a return period of once in ten years would be approximately 700 cfs. The flow in the Arkansas River at Muskogee during low flow conditions is dependent upon the flow in the Grand River, and the flow in the Grand River is controlled flow regulated by Ft. Gibson Dam. Flow regulation should be considered since it can change flow return periods.

Temperature Data - The average temperature of the regular samples taken during this survey was approximately 20°C. From figure B-11, it can be seen that temperatures equal to or less than this average would occur in 25% of the days in June to October.

Biological - Biological investigations in the Arkansas River in Oklahoma consisted of collecting bottom samples at nine stations along the river from Sand Springs to Webber Falls. Collections were made on October 7, 8, and 9. In addition to the Arkansas River, samples were collected from the Verdigris River at a location four miles above the mouth and from the Grand River two miles above the mouth. Data obtained from the samples collected in these rivers are contained in Table B-10.

The appearance of the river below Tulsa indicated that there was considerable pollution by oil and sewage. Consequently one station was selected above Tulsa and Sand Springs and the next station was selected five miles below Tulsa near Jenks. Above Sand Springs four types of organisms were found in limited numbers. They were collected near the shore in mud deposits. The stream bottom at this station was generally unstable and sandy except near some of the shore line. The organisms found at this station are probably rep-



TEMPERATURE FREQUENCY DISTRIBUTION
(WATER YEARS OCTOBER, 1948 — SEPTEMBER, 1950)
ARKANSAS RIVER
TULSA, OKLAHOMA

FIGURE B-11

resentative of the general area above Sand Springs.

Downstream below Tulsa near Jenks, heavy deposits of oil had collected on the stream bottom except where the flow was rapid. Walking was difficult because of the slipperyness of the oil on the exposed portions of stream bottom. At this station dead and dying minnows were found at certain places along the edge of the stream. The only animal forms found after a fairly extensive search in the flowing stream were snails (Physa) and bryozoa which were quite numerous. In the flowing stream, growths of bryozoa were common on the rocks and associated with them were an abundance of green algae including scenedesmus and several species of diatoms.

At Haskell, about 30 miles downstream from Jenks, there were greatly reduced amounts of oil deposits on the stream bottom in the areas where the waters had receded. Bottom fauna collected consisted of chironomid larvae and annelids which were both quite numerous. Filamentous green algae (Microspora) was abundant in the quiet areas along the edge of the stream. The stream had generally a sandy and rather unstable bottom at this station. Fishing was good near this station as evidenced by the large number of white bass that were being taken from the river by several fishermen.

At Muskogee, above the sewer outfalls, about twenty miles below the station near Haskell, a sample was collected from a rocky stream bottom where there was considerable current. Biological life was abundant. Large numbers of midge and caddis fly larvae were adhering to the stones. Also, lesser numbers of mayflies and damsel flies were found. Gelatinous masses of bryozoa were on the rocks and closely associated with them were green algae such as scenedesmus, selenastrum and diatoms. The biological population was rather high in this area. Below the north sewer outfall of Muskogee (the uppermost of two outfalls) the biological fauna was abundant and was composed of about the same types as at the previous station located above the outfall. Organisms requiring fairly high levels of oxygen such as the hellgrammites, caddis flies and dragon flies were found. The bottom was composed of sand and rock and considerable aeration of the water occurred.

A short distance above the south outfall at Muskogee large numbers of insect forms were found and in addition snails and annelids thrived. Indications at this station were that reaeration of the water was adequate to maintain fairly high oxygen levels and there was an abundance of food in the water to support the insect forms, snails, and annelids.

About two miles below the south sewer outfall at Muskogee the abundance of biological life was most striking. The stream was swift and contained a series of shoals making an ideal habitat for many of the insect forms. Midges, caddis flies, hellgrammites, dragon flies and damsel flies were very numerous. A large hellgrammite could be found under every rock measuring over four or five inches in diameter. Mayflies were also found though less numerous and some annelids were also collected. Bryozoa were fairly abundant on the rocks. The extremely large population of insect life indicated an abundance of food present in the water which was undoubtedly made available either directly or indirectly from the sewage discharged.

Eight miles below Muskogee at Smith's landing a variety of insect forms were found but in greatly reduced numbers. The stream bottom between this and the previous station was composed largely of sand with some shoal areas. It was mostly shallow but a few areas with deeper slowly moving water existed. At this station, green algae including cladophora, scenedesmus and diatoms were found in fairly great abundance. It was apparent that the food supply at this station had greatly diminished from that at the previous station.

At Webbers Falls, a river distance of 18 miles below Muskogee, the river bottom was generally sandy with a few rocks present. The current was fairly swift and much of the stream was shallow. Mayflies and midges were fairly numerous and fewer numbers of caddis flies and dragon flies were collected. The biological life collected at this station represented a more normal population of fauna.

Samples were collected from the Verdigris and Grand Rivers to obtain information on the abundance of biological life in these streams and to determine if the bottom fauna was significantly different from that in the Arkansas River either as to kinds or relative abundance.

In the Verdigris River, about four miles above the mouth, bottom fauna were collected. The river at this point had a fairly rapid current and flowed over a solid rock bottom. There were extremely large numbers of caddis flies and hellgrammites imbedded in masses of gelatinous producing bryozoa. Undoubtedly adequate aeration of the stream together with a large source of food was responsible for the very dense growth of organisms.

From the Grand River a moderately large number of insect forms were collected and a few clams. Though numerous, the numbers of insects were not considered excessive for the type of stream bottom which was rocky and contained shoal areas.

PART C

ARKANSAS RIVER

LITTLE ROCK, ARK., TO PINE BLUFF, ARK.
MILE 168.5 TO MILE 97.1
JULY 14, 1952 TO JULY 24, 1952

Part C

Arkansas River - Little Rock, Ark. to Pine Bluff, Ark.
Mile 168.5 to mile 97.1

Summary

Chemical and Bacteriological - No appreciable oxygen depletion was found below either Little Rock or Pine Bluff. The average dissolved oxygen concentration was 7.3 ppm. The five day BOD of the Arkansas River was increased with the addition of wastes from Little Rock and Pine Bluff. The maximum five-day BOD of 3.4 ppm occurred below Pine Bluff. The coliform density MPN increased below Little Rock and Pine Bluff; the maximum value occurring at Little Rock where the coliform MPN increased from a maximum of 2,400 per 100 ml. to 110,000 per 100 ml.

The construction of the proposed locks and dams above and below Little Rock and Pine Bluff and the resulting pooling of the river may cause some depletion of oxygen resources below Little Rock and Pine Bluff by decreasing the present reaeration rate of the river in these sections.

Biological - Bottom organisms collected from the Arkansas River above and below Little Rock and Pine Bluff, Arkansas, consisted of fly larvae and annelid worms. Because of an extremely unstable river bottom comparatively few organisms were collected from the stream.

Green algae, mostly spirogya, grew along the edges of the river in many places where the water was clear and quiet. Minnows were also observed in these areas. The presence of this biological life is significant since it indicates that the river system produces and supports some forms of beneficial aquatic life. Except for a few locations biological organisms did not indicate pollu-

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tion.

Introduction

The survey on the Arkansas River between Little Rock and Pine Bluff, Ark. was performed: (a) To determine water quality by chemical, biological and bacteriological tests. (b) To determine the amount of oxygen depletion below Little Rock and Pine Bluff, and locate the critical point of such depletion if any.

Description

General - The Arkansas River from Little Rock to Pine Bluff flows in a southerly direction. The drainage area above Little Rock contributing to the flow in the Arkansas River is 157,933 square miles. The country between Little Rock and Pine Bluff is level and blends into the Mississippi Valley area. At the time of the survey, a condition of low flow existed which limited river sampling. On the average, between these two cities, the river occupied between 15% to 25% of its bed.

The main tributaries to the Arkansas River in this area are the Little Maumelle River, Fourche Creek and Plum Bayou.

Economic Background - The Little Rock area is the principal marketing and industrial center in Arkansas. The main industry at Pine Bluff is the manufacturing of munitions (Pine Bluff Arsenal). In the country below Little Rock, agriculture consists mainly in the raising of cotton.

Water Uses

Public Water Supplies - Little Rock obtains its water supply from Lake Winona, formed by the impoundment of Alum Fork of the Saline River. It also has an emergency standby pumping station on the Arkansas River. Pine Bluff, however, obtains its water supply from wells, as do the other communities in this area.

Navigation - At the present time, there is some barge shipping between Pine Bluff and Little Rock. Navigation is extremely difficult in low water periods, because of the constantly shifting sand bottom.

It has been proposed that a series of locks and dams for navigation and power be installed on the Arkansas River. This would involve the installation of five locks and dams in the Little Rock-Pine Bluff area (See Diagram B-C1). Four of these dams are to be located in the stretch of river surveyed (Lock and Dam Nos. 6, 7, 8-A and 9-A).

Sources of Pollution

Domestic Pollution - A tabulation is presented in Table C-1 listing for various communities the population served by sewers, and the estimated population equivalent of wastes discharged into the stream. Little Rock, North Little Rock, and Pine Bluff contribute nearly all of the domestic sewage load. Not included in this table is the pollution caused by the dumping of domestic garbage into the Arkansas River by the city of North Little Rock. Since the survey, Pine Bluff now discharges all of its wastes to the Arkansas River.

Industrial Pollution - In Greater Little Rock there are 287 manufacturing plants (as of 1950). These plants produce a wide variety of products, the main product being aluminum and aluminum products.

Survey Methods

Location of Sampling Stations - Since there was only one bridge available for sampling between Little Rock and Pine Bluff, it was necessary to take most of the samples from a boat. This, however, was extremely difficult because of the low flow conditions, shifting sand bottoms, and meanderings of the channel.

Plate C-2 shows the locations of the sampling stations used during the survey. Table C-2 is a listing of these stations, with their mileage, and description.

Normal Sampling Procedure - A standard copper 1 gallon capacity 3 bottle sampler was used for taking samples. All of the samples, with the exception of those taken at mile 165.8 were taken in the center of the existing channel. Three samples were taken at 3:00 AM at mile 165.8 for dissolved oxygen determination, to determine if there was any algae activity in this stretch of the river. Such activity would be shown by significantly lower D.O. values at night than during daylight assuming no fluctuation in the volume and strength of wastes from sources of pollution. Plankton samples were also obtained.

Whenever a sample was taken, time, temperature and any descriptive remarks that would explain special conditions, were recorded on standard field data sheets.

Presentation of Data

Water Quality - Three hundred and forty-five physical and chemical determinations were performed on 69 samples; 18 samples were taken for bacteriological analysis. Table C-3 is the summary of the analytical results of the tests made on the samples obtained during this survey. For each station, number of samples taken, maximum, minimum and mean values are listed for D.O., B.O.D., temperature, per cent saturation, nitrates, phosphates, chlorides, turbidity, color and alkalinity. A median is used in place of the mean for the coliform MPN results. Table C-4 in the appendix is a complete listing of all the laboratory data.

A graphical presentation of the D.O. and B.O.D. results is presented in Figure C-3. The data obtained on the coliform densities, in terms of MPN, is presented in Figure C-4.

Hydrologic Data - The flow data for the various sampling points for the days

TABLE C-1

DOMESTIC SOURCES OF POLLUTION

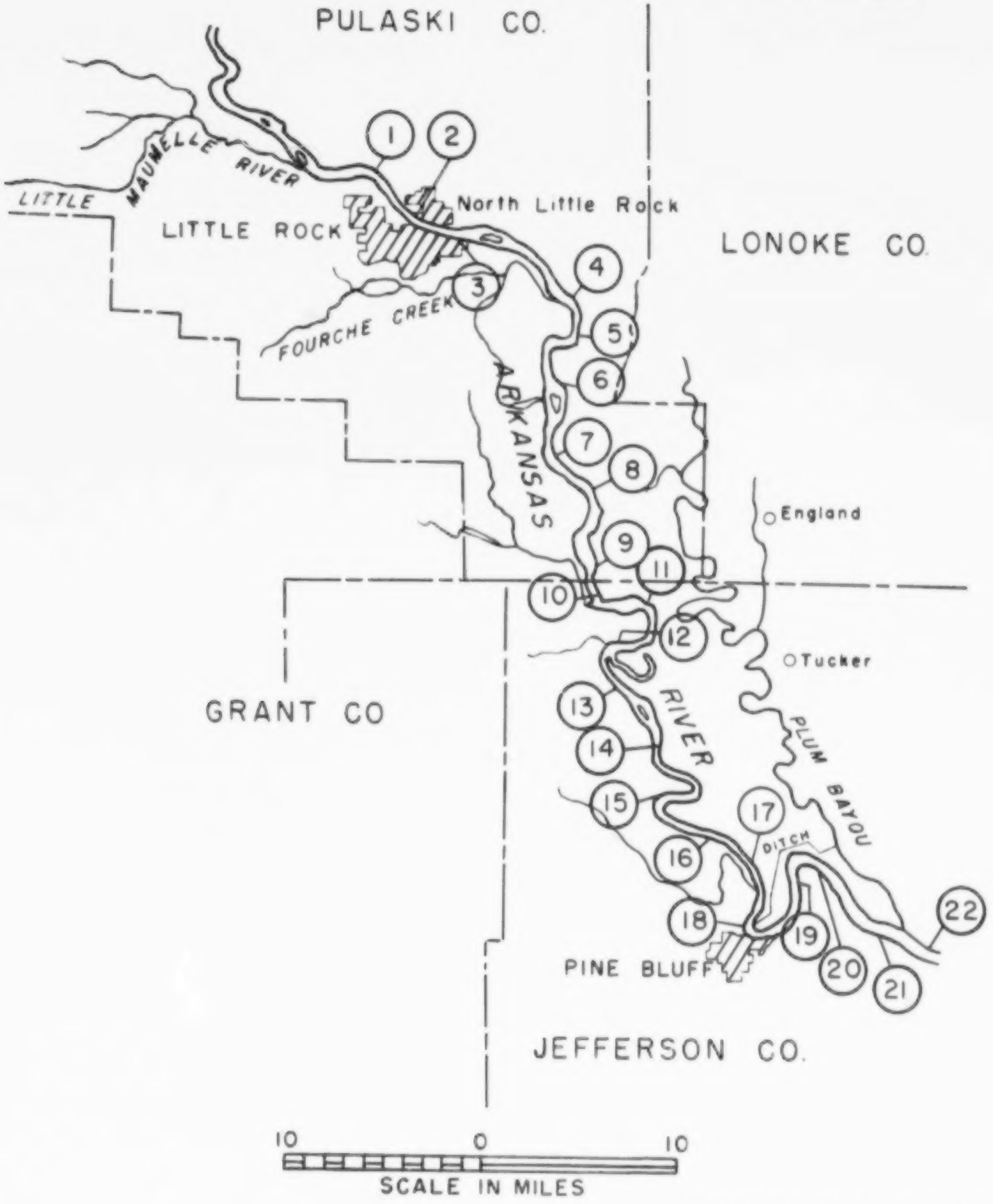
Arkansas River - Mile 168.5 to 97.1

Water Course and Municipality	River Mile	Est. Pop. Served By Sewers	Treatment	Est. P.E. Disch To Water Course
Arkansas River				
Little Rock	162-167	95,000	None	95,000
North Little Rock	162-166	22,000	None	22,000
Drainage Ditch from Plum Bayou	112			
England		2,000	Primary	1,400
Tucker Prison Farm		400	Primary	300
Pine Bluff	110-111.5	23,000	(2/3 sewage direct to Arkansas River)* None	15,000

* At the present time Pine Bluff discharges all of its sewage into the Arkansas River.

TABLE C-2
SAMPLING STATIONS
ARKANSAS RIVER-MILE 168.5 TO 97.1

Sampling Station	Mileage	Description	No.Days Sampled
1	168.5		3
2	165.8	U.S.67,70,65 & 167 Highway Bridge at Little Rock	3
3	164.0	1 1/2 miles above N.Little Rock Garbage Dump 0.8 mile downstream from C.R.I & P.R.R.Bridge	3
4	158		3
5	155.0		3
6	152.0		3
7	149.0		3
8	146.0	Warings Bend	3
9	141.0		3
10	138.0		3
11	135.0	1/2 mile above Plum Bayou	3
12	132.0	Tar Camp Crossing	3
13	129.0		3
14	126.0		3
15	123.0	Tripletts Bluff	3
16	120.0		3
17	115.6	U.S. 79 Highway Bridge	7
18	112.0	1/2 mile above Pine Bluff	3
19	108.0		2
20	104.6	Roan Landing	2
21	100.0		2
22	97.1	Madding Ferry	2


PULASKI CO.
1
2
North Little Rock
LITTLE
MAUMELLE RIVER
LITTLE ROCK
LONOKE CO.
4
3
FOURCHE CREEK
5
6
ARKANSAS
7
8
England
9
11
10
12
Tucker
GRANT CO
RIVER
13
14
PLUM BAYOU
15
17
DITCH
16
18
19
22
PINE BLUFF
20
21
JEFFERSON CO.
10
0
10
SCALE IN MILES

SAMPLING STATIONS
ARKANSAS RIVER
LITTLE ROCK, ARK. TO
PINE BLUFF, ARK.
FIGURE NO. C-2

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 1 of 5)

Table C-3 - Summary of Individual Results, Sanitary Examination, Arkansas River, Mile 168.5 to 97.1

Station	Samples	Flow, CFS at Little Rock Arkansas	5-day B.O.D. 20° C, ppm	D.O. ppm	Temper-ature, °C.	Per Cent Saturation	Nitrates as N, ppm	PO_4 ppm	Cl^- ppm	Turbidity ppm	Color, ppm	pH	Alkalinity ppm	Coliforms MPN per 100 ml.
Mile-168.5	No Samp	3	3	3	3	3	3	3	3	3	3	3	3	2
	Mean	5903	1.6	7.1	29	91	0.120	0.09	357		7		163	
	Max.	6750	1.8	7.3	30	95	0.300	0.12	390	30	10	8.3	175	2,400
	Min.	5060	1.2	6.9	28	87	0.030	0.08	320	<25	5	7.9	149	930
Mile-165.8	No Samp	3	3	3	3	3	3	3	3	3	3	3	3	3
	Mean	6950	2.4	7.6	29	99	0.037	0.07	371		5		143	
	Max.	7850	2.9	8.1	30	100	0.040	0.08	541	29	5	8.5	153	110,000
	Min.	6500	2.2	7.1	29	96	0.030	0.06	274	<25	5	8.0	137	910
Mile-164	No Samp	3		3	3	3								
	Mean	5903		6.7	29	88								
	Max.	6750		6.8	30	90								
	Min.	5060		6.6	28	83								
Mile-158	No Samp	3	2	3	3	3	3	3	3	3	3	3	3	2
	Mean	5903	2.6	7.2	29	94	0.083	0.13	374		8		162	
	Max.	6750	2.8	7.7	30	100	0.200	0.14	462	40	10	8.3	176	43,000
	Min.	5060	2.3	6.7	28	85	0.020	0.12	329	<25	5	7.9	140	15,000
Mile-155	No Samp	3		3	3	3								
	Mean	5903		7.5	30	99								
	Max.	6750		7.9	31	110								
	Min.	5060		6.8	29	88								

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 2 of 5)

Table C-3 - Summary of Individual Results, Sanitary Examination, Arkansas River, Mile 168.5 to 97.1

Station	Samples	Flow, CFS at Little Rock Arkansas	5-day B.O.D. 20° C, ppm	D.O. ppm	Temper-ature, °C.	Per Cent Saturation	Nitrates as N, ppm	PO_4 ppm	Cl^- ppm	Turbidity ppm	Color, ppm	pH	Alkalinity ppm	Coliforms MPN per 100 ml.
Mile-152	No Samp	3		3	3	3								
	Mean	5903		7.3	29	96								
	Max.	6750		7.5	30	99								
	Min.	5060		6.5	29	90								
Mile-149	No Samp	3		3	3	3								
	Mean	5903		7.7	29	101								
	Max.	6750		8.1	30	110								
	Min.	5060		7.1	29	92								
Mile-146	No Samp	3		3	3	3								
	Mean	5903		7.6	30	97								
	Max.	6750		8.0	31	100								
	Min.	5060		7.1	29	92								
Mile-141	No Samp	3	3	3	3	3	3	3	3	3	3	3	3	2
	Mean	5903	2.2	7.6	29	101	0.080	0.10	381		7		170	
	Max.	6750	2.8	8.0	30	110	0.120	0.12	513	35	10	8.3	180	43,000
	Min.	5060	1.8	7.3	29	95	0.020	0.08	304	<25	5	7.9	155	24,000
Mile-138	No Samp	3		3	3	3								
	Mean	5903		7.9	30	105								
	Max.	6750		8.4	30	110								
	Min.	5060		7.2	29	94								

ARKANSAS-WHITE-RED FIELD STUDIES

Table C-3 - Summary of Individual Results, Sanitary Examination, Arkansas River, Mile 168.5 to 97.1 (Sheet 3 of 5)

Station	Samples	Flow, CFS at Little Rock Arkansas	5-day B.O.D. 20° C, ppm	D.O. ppm	Temper-ature, °C.	Per Cent Saturation	Nitrates as N, ppm	PO$_4$ ppm	Cl$^-$ ppm	Turbidity ppm	Color, ppm	pH	Alkalinity ppm	Coliforms MPN per 100 ml.
Mile-135	No Samp	3		3	3	3								
	Mean	5903		7.6	30	100								
	Max.	6750		7.9	30	104								
	Min.	5060		7.1	29	92								
Mile-132	No Samp	3		3	3	3								
	Mean	5903		7.7	29	102								
	Max.	6750		8.4	31	110								
	Min.	5060		6.7	28	87								
Mile-129	No Samp	3		3	3	3								
	Mean	5903		7.7	29	102								
	Max.	6750		8.1	30	110								
	Min.	5060		6.9	28	87								
Mile-126	No Samp	3		3	3	3								
	Mean	5903		7.8	30	103								
	Max.	6750		8.2	31	110								
	Min.	5060		7.1	28	90								
Mile-123	No Samp	3	3	3	3	3	3	3	3	3	3	3	3	2
	Mean	5903	2.1	7.9	29	103	0.107	0.11	365		5		175	
	Max.	6750	3.3	.4	30	110	0.200	0.14	503	45	5	8.3	180	28,000
	Min.	5060	1.3	6.9	28	88	0.050	0.08	273	<25	5	8.0	164	9,300

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 4 of 5)

Table C-3 - Summary of Individual Results, Sanitary Examination, Arkansas River, Mile 168.5 to 97.1

Station	Samples	Flow, CFS at Little Rock Arkansas	5-day B.O.D. 20° C, ppm	D.O. ppm	Temper-ature, °C.	Per Cent Saturation	Nitrates as N, ppm	PO_4 ppm	Cl^- ppm	Turbidity ppm	Color, ppm	pH	Alkalinity ppm	Coliforms MPN per 100 ml.
Mile-120	No Samp	3		3	3	3								
	Mean	5903		7.9	30	101								
	Max.	6750		8.5	30	110								
	Min.	5060		7.3	29	94								
Mile-115.6	No Samp	7	7	7	7	7	7	7	7	7	7	7	7	5
	Mean	6480	2.3	7.4	30	96	0.080	0.09	382		6		172	2300
	Max.	8150	2.8	8.0	31	100	0.120	0.12	522	46	10	8.3	185	9300
	Min.	5060	1.9	6.8	28	87	0.030	0.08	297	<25	5	7.7	142	91
Mile-112	No Samp	3		3	3	3								
	Mean	5903		7.7	30	100								
	Max.	6750		8.2	30	110								
	Min.	5060		7.1	29	91								
Mile-108	No Samp	2		2	2	2								
	Mean	6500		7.3	29	93								
	Max.	6500		7.8	30	100								
	Min.	6500		6.7	28	85								
Mile-104.6	No Samp	2	2	2	2	2	2	2	2	2	2	2	2	1
	Mean	6500	3.4	8.0	29	105	0.115	0.10	298	34	5		179	V = 7500
	Max.	6500	5.1	8.1	30	110	0.200	0.14	311	36	5	8.2	180	
	Min.	6500	1.7	7.8	28	99	0.030	0.06	273	33	5	7.9	178	

ARKANSAS-WHITE-RED FIELD STUDIES

Table C-3 - Summary of Individual Results, Sanitary Examination, Arkansas River, Mile 168.5 to 97.1 (Sheet 5 of 5)

Station	Samples	Flow, CFS at Little Rock Arkansas	5-day B.O.D. 20° C, ppm	D.O. ppm	Temper- ature, °C.	Per Cent Saturation	Nitrates as N, ppm	PO_4 ppm	Cl^- ppm	Turbidity ppm	Color, ppm	pH	Alkalinity ppm	Coliforms MPN per 100 ml.
Mile 100	No Samp	2		2	2	2								
	Mean	6500		7.4	29	95								
	Max.	6500		7.6	30	100								
	Min	6500		7.1	28	90								
Mile 97.1	No Samp	2	2	2	2	2	2	2	2	2	2	2	2	1
	Mean	6500	1.8	7.3	29	94	0.025	0.12	292	32	8		184	V = 46000
	Max.	6500	1.9	7.5	30	99	0.030	0.14	311	40	10	8.2	185	
	Min.	6500	1.7	7.0	28	88	0.020	0.10	273	25	5	7.8	182	

Table C-6 - Bottom Organisms, Arkansas River
Near Little Rock and Pine Bluff
(Collected July, 1952)

Station	Insects	Mollusca	Annelida	Remarks
Mile 168.5 Little Rock	Diptera Chironomidae, numerous			Sandy - green algae, Spirogyra
Mile 165 Rock Island Bridge	Diptera Tipulidae, few Family(?), few		Numerous	Sand and mud bottom - green algae, Spirogyra, Zygnema
Mile 158 below Little Rock			Few	Sand and mud
Mile 115.6 Hwy.79 Bridge near Pine Bluff	Diptera Ceratopogonidae, few			Silt and sand bottom
Mile 107 below Pine Bluff	(Surface of wat also on bottom	er covered)	Few with oil.	Sand and gravel bottom - Oil deposits

sampled are summarized, along with the analytical results in Table C-3, and presented in their entirety in Table C-4. Graph C-5 is a hydrograph of the Arkansas River at Little Rock, during the period of the survey. Table C-5 contains the tabulation of the flows for the period covered in the hydrograph. The results of an analysis of past flow data on the Arkansas River at Little Rock covering the period 1934 to 1950 is presented in Figure C-6.

Temperature Data - Analyses were made of temperature frequency distribution covering the average daily water temperature for the months of June to October, water years October 1945 to September 1949. The results of these analyses are presented in Figure C-7.

Biological - Data collected during the biological phase of this survey are tabulated in Table C-6.

Discussion

Water Quality

Dissolved Oxygen - Figure C-3 contains the plot of the mean and minimum dissolved oxygen for the stretch of river surveyed, the dissolved oxygen remains fairly constant for the complete length of stream. Considering all the sampling stations, the mean dissolved oxygen concentrations ranged from 6.7 ppm to 7.9 ppm, or 88 and 105% of saturation. The lowest dissolved oxygen concentration occurred at mile 164. This station is located downstream from all of Little Rock's sewer outfalls, and above the garbage dump of North Little Rock.

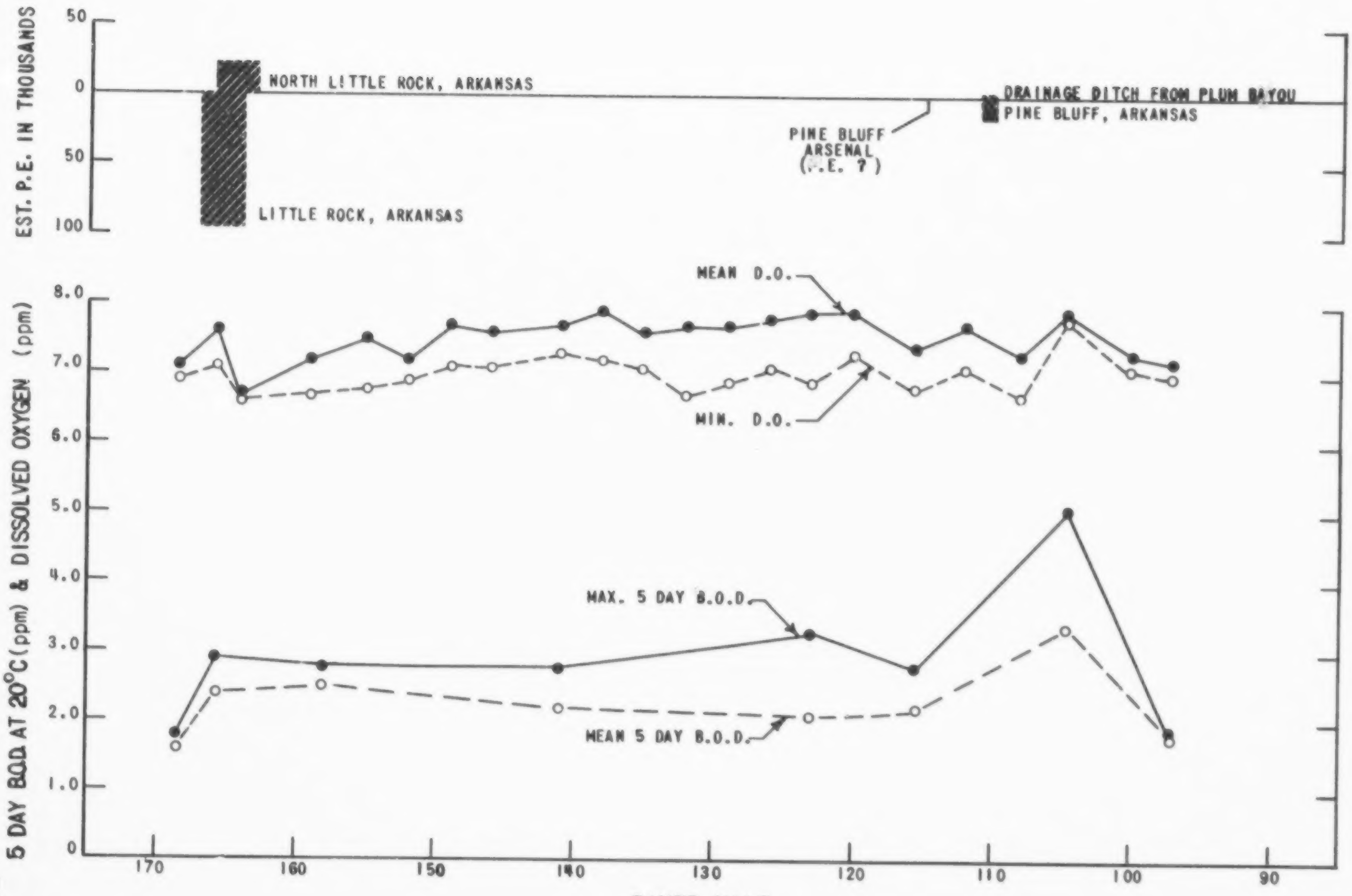
The pooling of the river resulting from the proposed installation of locks and dams at mile 153.5, 145.0, 128.0 and 102.9, will cause the river to lose its reaeration characteristics that are indicated in the survey results. However, such pooling will create conditions favorable for a much greater growth of algae than was present during this survey. Increased algae growth will increase the dissolved oxygen concentration in the river during daylight hours but will lower the dissolved oxygen concentration considerably at night. The river pooled behind locks and dams No. 9-A (mile 153.5) below Little Rock and North Little Rock's outfalls, will probably act as a settling basin permitting the solids in the wastes discharged by these municipalities to settle out and form sludge banks behind the lock and dam during periods of low flow. The same condition will probably exist below Pine Bluff upon installation of Lock and Dam No. 6 (mile 102.8). If this occurs, the benthal demand exerted by these sludge banks may cause two areas of oxygen depletion below Little Rock and North Little Rock, and below Pine Bluff. The oxygen depletion may be greater than the values found during this survey.

Five-day BOD at 20° - Table C-3 and figure C-3 show that the BOD of the stream increases as it passes the Little Rock area (mile 168.5) from a mean value of 1.6 ppm to 2.4 ppm at mile 165.8. At mile 104.6 below the outfalls from Pine Bluff Arsenal, the city of Pine Bluff, and the drainage ditch from Plum Bayou, the mean 5-day BOD was 3.4 ppm.

Temperature - During the survey the temperature of this 71.4 mile stretch of fiver ranged between 28 and 31° C., averaging 29.5° C. The temperature of the water on the 24th of July, at 3:00 AM, was 30° C.

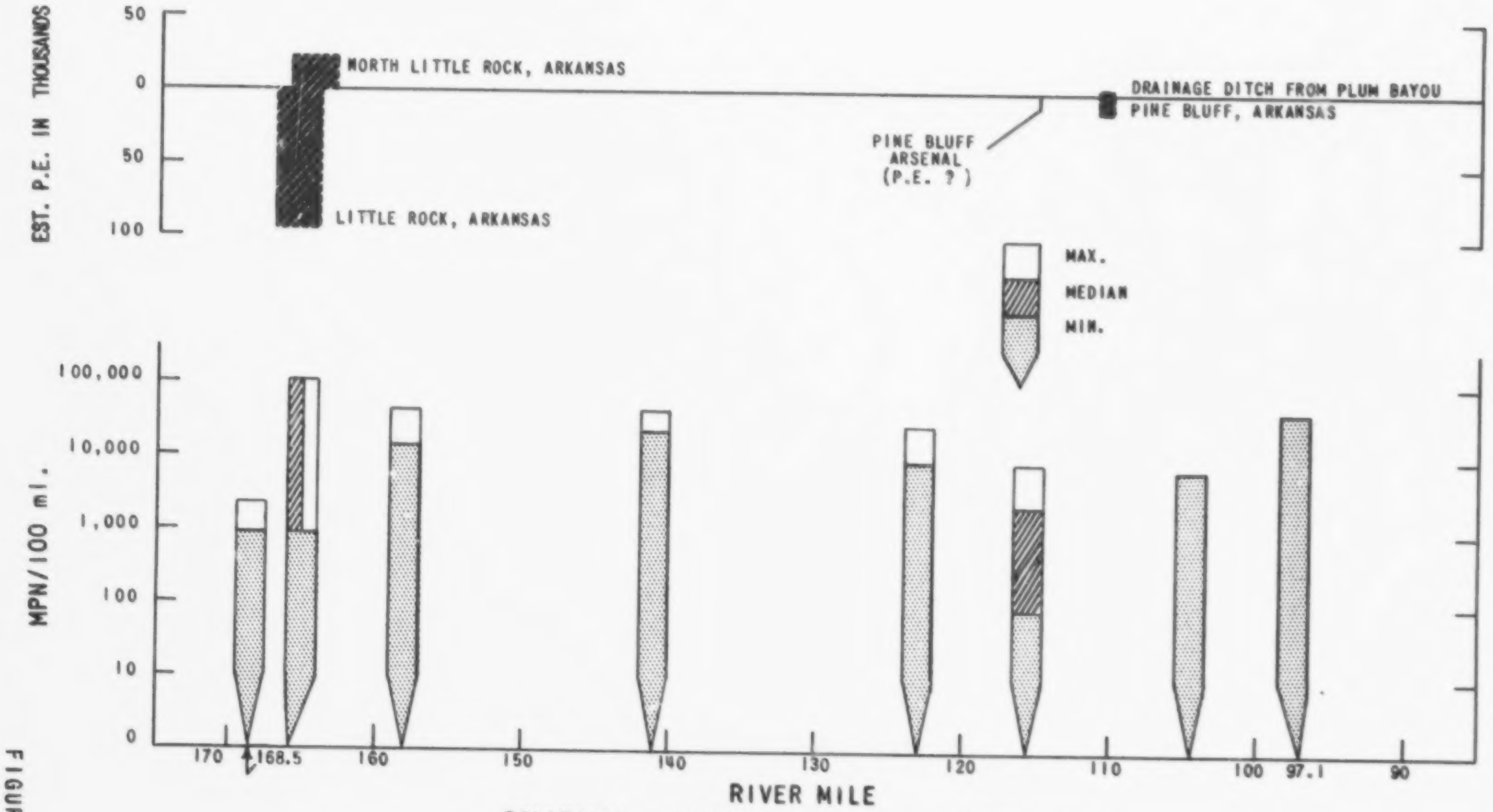
Nitrates as N - During the period of this survey, the nitrates ranged between 0.020 and 0.300 ppm, averaging 0.082 ppm. At mile 165.8, the nitrates ranged from 0.030 to 0.040 ppm, averaging 0.037 ppm.

Phosphates (PO_4) - The phosphate concentrations found in the Arkansas River during the survey, were fairly constant ranging from 0.06 ppm to 0.14 ppm, and averaging 0.10 ppm. These concentrations of phosphate could support



DISSOLVED OXYGEN & 5 DAY B.O.D. AT 20°C. vs. RIVER MILE
ARKANSAS RIVER
(JULY 14 TO 24, 1952)

FIGURE C-3



COLIFORM MPN/100ml vs. RIVER MILE
ARKANSAS RIVER
(JULY 14 TO 24, 1952)

FIGURE C-4

the activity of most algae.

Chlorides (Cl^-) - The mean chloride concentration, for all the stations sampled during the survey, was 361 ppm, the maximum and minimum being 541 and 273 ppm. The mean chloride concentrations of each station remained fairly constant from mile 168.5 to mile 115.6. Below the Pine Bluff area the mean chloride concentration decreased from 382 ppm to 298 ppm at mile 104.6.

Turbidity - The turbidity of the Arkansas River in this area, during the survey, ranged from < 25 to 46 ppm.

Color - Referring to Table C-3 the color of the stream ranged from 5 ppm to 10 ppm and averaged 6 ppm.

pH - The hydrogen ion concentration remained fairly constant for this stretch of the Arkansas River, varying from pH 7.7 to 8.5.

Total Alkalinity - The alkalinity at the various stations averaged 168 ppm. The individual alkalinity concentrations varied from 137 ppm to 185 ppm. There was no pattern of increase or decrease established by the test results of this survey.

Coliform Densities - MPN - Figure C-4 is a plot of the MPN values obtained from the various stations. The data show an increase in coliform densities in the Arkansas River below Little Rock and North Little Rock as would be expected.

Hydrologic Data - Figure C-5 is a plot of an analysis made on the flow records of the Arkansas River at Little Rock, covering the years 1934 to 1950. The average monthly flows for the months of June, July, August, September and October of each year (1934-50) were examined and the minimum monthly average flow was selected from these months for each year.

The average flow in the Arkansas River at Little Rock during the period of the survey was 6,337 cfs. If we assume that this flow is representative of a monthly average flow, then referring to the plot in Graph C-6 we find that this flow has a return period of about once every two years.

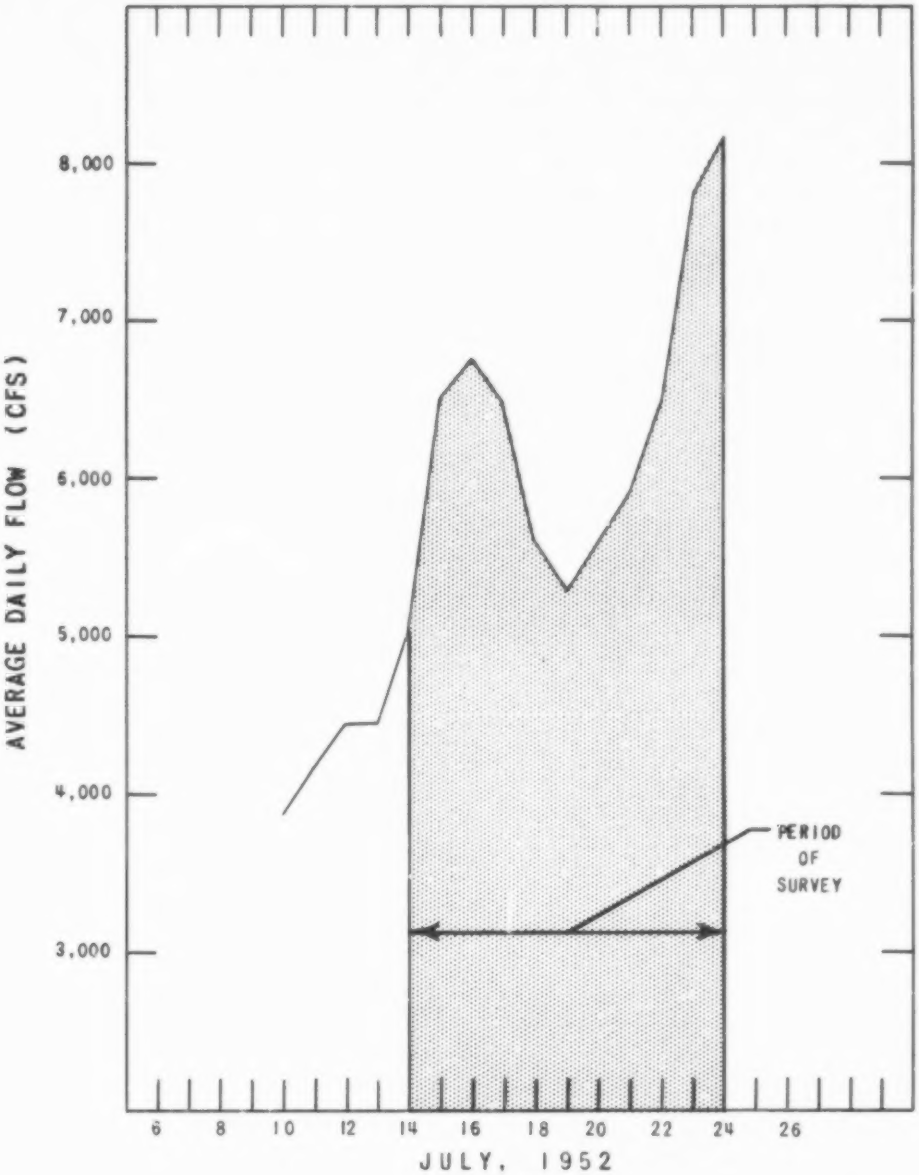
Temperature Data - Figure C-7 is a water temperature frequency distribution as determined by analysis of available records. The average water temperature during the survey was 29.5°C; referring to this distribution a temperature equal to or greater than this value would be expected for 10 per cent of the days in the months June to October.

Biological - Biological samples were collected from the Arkansas River in the vicinity of Little Rock and Pine Bluff. The river in these areas is characterized by extremely unstable bottoms. River depths at Little Rock have been known to vary several feet from one day to the next because of shifting sand. Statements to describe the unstable bottom have been made by personnel familiar with the river to the effect that when increased flows occur "the bottom goes into solution." Bottom fauna that were collected are listed in Table C-6.

Above Little Rock at river mile 168.5, the only bottom fauna collected were midge larvae. These were fairly numerous. It was noticed that in the quiet water areas along the shore abundant growths of filamentous algae were present, most of which were spirogyra. A large number of small minnows were also seen along the shore.

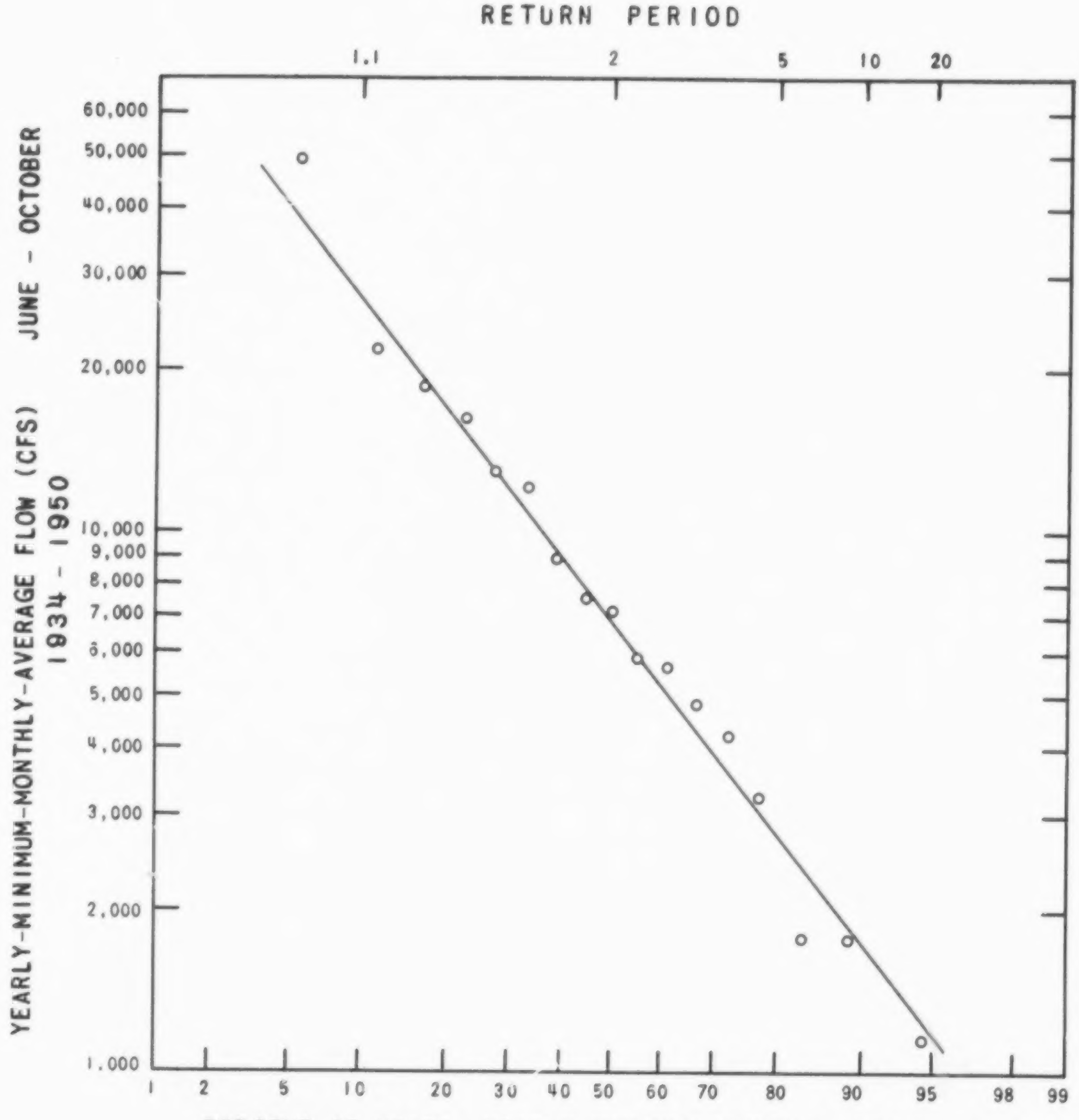
Below a number of the Little Rock sewer outfalls at the Rock Island Railroad bridge numerous annelids, a few cranefly larvae and larvae of an unidentified family were collected. Chironomids were not found. Green algae consisting of spirogyra and zygnema were fairly abundant.

At mile 158 which was about 7 miles below Little Rock only a few annelids were found. The bottom in this reach of the river below Little Rock was very unstable and composed of fine sand which made collection of bottom organisms



HYDROGRAPH
ARKANSAS RIVER
LITTLE ROCK, ARKANSAS

FIGURE C-5

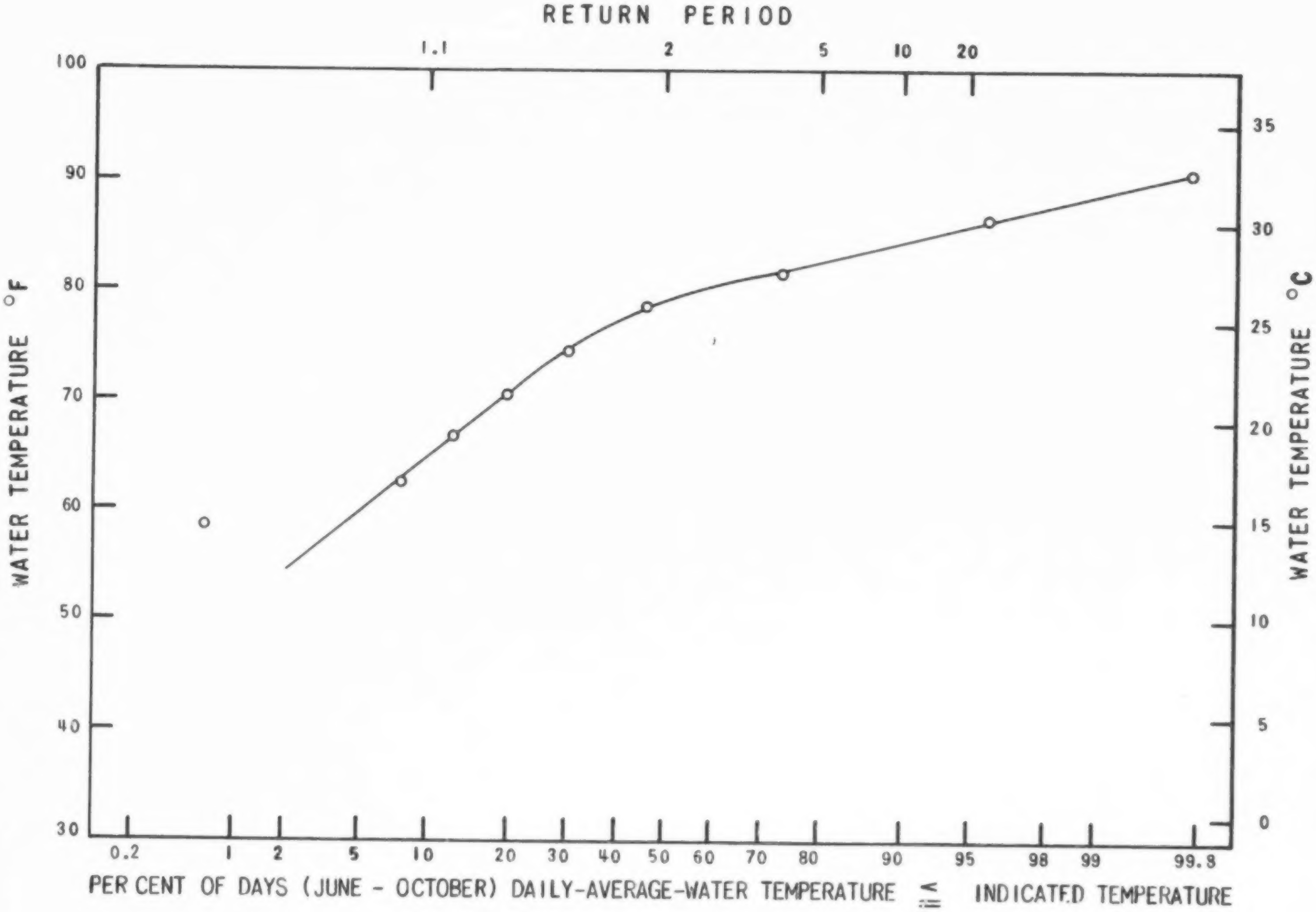


PERCENT OF YEARS, YEARLY-MINIMUM-MONTHLY-AVERAGE FLOW, (JUNE - OCTOBER) ≧ INDICATED FLOW

FLOW FREQUENCY DISTRIBUTION

ARKANSAS RIVER
LITTLE ROCK, ARKANSAS

FIGURE C-6



TEMPERATURE FREQUENCY DISTRIBUTION
(WATER YEARS OCTOBER, 1945 - SEPTEMBER, 1948)

ARKANSAS RIVER
LITTLE ROCK, ARKANSAS

FIGURE C-7

difficult.

Above Pine Bluff at mile 115.6, only a few midge larvae were collected from the fine silt. At this station large numbers of minnows were observed swimming close to the shore. Several small gar were also observed near these schools of minnows and were apparently feeding upon them.

Below Pine Bluff the surface of the water was covered with oil. Deposits of oil sludge were also on the bottom. Sand and gravel composed the bottom where the sample was collected. A few annelids were the only organisms in the sample.

Organisms collected in the Little Rock and Pine Bluff areas were comparatively few in number and kind. The unstable bottom is perhaps mainly responsible for the scarcity of bottom fauna. It is believed, however, that more intensive sampling of the areas would yield a much larger variety of organisms.

PART D

OUACHITA RIVER
ARKADELPHIA, ARK. TO RICHARDSON'S FERRY, ARK.
MILE 418.5 TO MILE 400
JULY 28, 1952 TO AUGUST 2, 1952

Part D

Ouachita River - Arkadelphia, Ark. to Richardson's Ferry, Ark.
Mile 418.5 to Mile 400.0

Summary

Chemical and Bacteriological - Arkadelphia discharges its sewage into the Ouachita River between miles 416 and 415. These wastes increased the coliform MPN from a maximum value of 1,500 per 100 ml. to a maximum of 430,000 per 100 ml. The minimum dissolved oxygen concentration obtained between mile 416.0 and mile 400.0 was 5.5 ppm and the maximum five day BOD was 1.2 ppm. The discharge of Arkadelphia's sewage into the Ouachita does not measurably affect the dissolved oxygen content or BOD due to considerable dilution. However, the effect of Arkadelphia's sewage on the river is reflected in the high coliform MPN values. These MPN values should be considered in any proposed use of the Ouachita River below mile 415.0 as a source of public water supply.

Biological - Collection of bottom life from the Ouachita River near the Arkadelphia sewer outfalls indicated that sewage from Arkadelphia stimulated the growth of annelid worms (Tubifex). These annelids are indicators of pollution because of their dependence upon solid food deposits.

About three miles below Arkadelphia, the stream changes from a wide, slowly moving body of water to a narrow, swiftly flowing stream. This type of environment provides a favorable oxygen supply to the aquatic animals. The presence of adequate oxygen together with an abundant food supply stimulates large numbers of a variety of organisms. It is apparent that, although the dissolved oxygen and biochemical demand results do not show the presence of significant amounts of pollution, biological data indicate that sewage from Arkadelphia has a considerable influence on the growth of biological life three miles below the point of discharge of sewage.

Introduction

This survey, initiated on July 28, 1952, and covering the period July 28 to August 2, 1952, was originally planned to cover the section of river from above Arkadelphia, Ark. (mile 418.5) to Nix's Ferry (mile 387). However, conditions were such that it was impossible to proceed downstream further than Richardson's Ferry (mile 400.0), below which the river was blocked by fallen trees.

The purpose of the survey was twofold: (a) to obtain sufficient data to indicate the extent and distribution of coliform organisms in the stream due to the discharge of sewage from Arkadelphia, and (b) to obtain chemical and biological data relating to the stream conditions in this section.

Description

General - The Ouachita River is in the Red River Drainage Basin. At Arkadelphia it flows in a general southerly direction; the river above Arkadelphia drains 2,311 square miles. The land on either side of the river is hilly, having a dense growth of trees and brush on either shore. The river at Arkadelphia consists of a series of ponded areas divided by shoal areas and is unaffected by the locks and dams further downstream. The only means of obtaining water samples was by boat, low flow conditions making sampling and navigation most difficult. It usually took seven hours to go from mile 418.5 to mile 400.0, a distance of 18.5 miles.

Economic Background - The city of Arkadelphia has a limited amount of industry. Two colleges, Henderson State Teachers College and Ouachita Baptist College are located in Arkadelphia. Principal crops in this area include corn, hay, fruits, with cotton being the main produce. To the south of Arkadelphia, there is some terrace rice farming. At the present time, Reynolds Metal Company has under construction an aluminum plant south of Arkadelphia.

Water Uses

Water Supply - Arkadelphia, population 6,796 (1950 census), obtains its water supply, 0.50 MGD, from the Ouachita River. The farms in the area around Arkadelphia obtain their water from wells. The Reynolds Metal Company will obtain its water supply from the river (3 MGD for process and domestic water).

Navigation - In the March 1949 edition of "Maps of Ouachita and Black Rivers," the city of Arkadelphia is listed as the head of navigation on the Ouachita River. The river is not used for navigation above the city of Camden, 63.5 miles downstream from Arkadelphia. The proposed removal of the locks and dams located downstream will have no effect on the river at Arkadelphia.

Fishing - A fair amount of sport fishing is carried on in this area. The fishing conditions are excellent and the fish are plentiful.

Sources of Pollution

Domestic Sewage - The city of Arkadelphia discharges untreated wastes of an estimated 6,000 people into the Ouachita River. There are two outfalls, the larger, furthest downstream, carrying approximately 2/3 of the load; a small sludge bank was observed below the second outfall. The city dump is situated just below the lower sewage outfall and extends into the river with its drainage seeping to the river.

Industrial Wastes - Pollution from industrial sources in this area is minor.

The Reynolds Metal Company plans complete treatment with chlorination of its domestic sewage.

Survey Methods

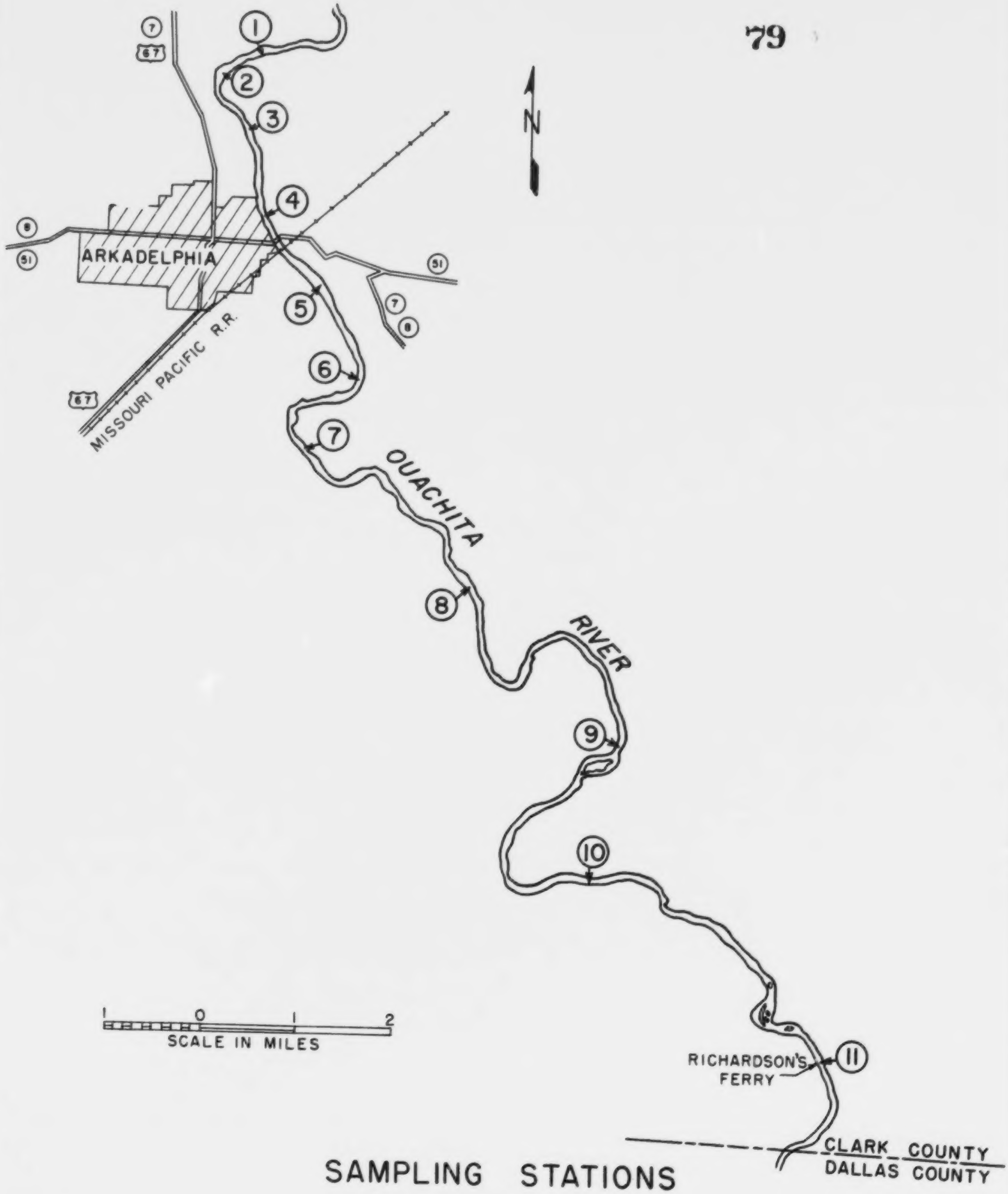
Location of Sampling Stations - Plate D-1, shows the general location of the sampling stations for this survey on the Ouachita River. The sampling points, with their mileages and descriptions, are listed in Table D-1. Samples for coliform organisms, dissolved oxygen, and biochemical oxygen demand determinations were taken midstream and at quarter points above and below the outfalls from Arkadelphia to obtain an indication of the degree of dispersion of the sewage in the river. Elsewhere samples were taken only in midstream.

Sampling Procedures - A standard copper, one gallon capacity, 3 bottle sampler was used for taking the samples. Two of the bottles were for D.O. and B.O.D. samples while the third bottle was for the bacteriological sample. With the exception of the quarter point samples mentioned above, all samples were taken at the centerline of the river channel and at a three foot depth whenever feasible.

Whenever a sample was taken, time, temperature, and any descriptive remarks that would explain unusual conditions, were recorded on standard field data sheets.

Presentation of Data

Water Quality - Thirty-four samples were taken for bacteriological analysis, while 233 physical and chemical determinations were made on 47 samples. The results of the bacteriological, chemical and physical tests are summarized in Table D2. These include maximum and minimum values for the coliform density MPN tests made at the various stations. Maximum, minimum and mean values for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51
ARKADELPHIA
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67
MISSOURI PACIFIC R.R.
N
OUACHITA
RIVER
1 0 1 2
SCALE IN MILES
RICHARDSON'S FERRY
CLARK COUNTY
DALLAS COUNTY

SAMPLING STATIONS
OUACHITA RIVER
ARKADELPHIA, ARK.

FIGURE D-1

Table D-1 - Sampling Stations, Ouachita River, Arkadelphia, Ark., to Richardson's Ferry, Ark.

Sampling Station	River Mile	Description	Number of Days Sampled
1	418.5		2
2	418.0	20 yards above pipeline submarine crossing	5
3	417.0		3
4	416.0	400 yards upstream from State Highway 51 Bridge	3
5	415.0	1/2 mile below Missouri-Pacific R.R. Bridge	4
6	414.0		2
7	413.0		2
8	410.0		2
9	407.0		2
10	404.0	400 yards above pipeline submarine crossing	2
11	400.0	At Richardson's Ferry	2

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 1 of 3)

Table D-2 - Summary of Individual Results, Sanitary Examination - Ouachita R., Miles 418.5 - 400.0

Station		Samples	Flow, c.f.s. Arkadelphia, Ark.	Coliforms MPN per 100 ml	B.O.D. 5-day 20°C, ppm	D.O. ppm	Temperature, °C	Per cent Saturation	Cl^- ppm	Nitrates as N, ppm	PO_4^{---} ppm	Color, ppm	Turbidity ppm	pH	Total Alkalinity, ppm
Mile 418.5	C	Number	2	2		2	2		1	1	1	1	1	1	1
		Mean	229			5.9	29.5	76	9	0.015	0.020	10			34
		Maximum	266	9,300		6.0	30	78					< 25	6.9	
		Minimum	190	390		5.7	29	73					< 25	6.9	
Mile 418															
1/4 pt.Right Bank		Number				1	1								
		Value				5.82	29	75							
	C	Number	5	4	3	5	5		4	4	4	4	4	4	4
		Mean	226		1.2	6.1	29.6	79	8	.023	.043	11.3			32.5
		Maximum	266	1,500	2.3	6.8	30	90	9	.040	.090	15	< 25	6.9	38
		Minimum	190	230	0.3	5.7	29	73	8	.015	.020	10	< 25	6.8	32
1/4 pt.Left Bank		Number				1	1								
		Value				5.73	29	74							
Mile 417															
1/4 pt.Right Bank		Number		2	2	3	3								
		Mean			0.5	5.7	29.3	74							
		Maximum		24,000	0.7	5.8	30	77							
		Minimum		360	0.2	5.7	29	73							
	C	Number	3	3	2	2	3		1	1	1	1	1	1	1
		Mean			0.4	5.8	29.7	76	8	.013	.030	15			36
		Maximum	266	430	0.5	5.9	30	78					< 25	6.9	
		Minimum	190	430	0.3	5.7	29	74					< 25	6.9	

C - Centerline

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 2 of 3)

Table D-2 - Summary of Individual Results, Sanitary Examination - Ouachita R., Miles 418.5 - 400.0

Station	Samples	Flow, cfs, at Arkadelphia, Ark.	Coliforms MPN per 100 ml	5-day B.O.D. 20°C, ppm	D.O. ppm	Temperature, °C	Per cent Saturation	Cl⁻ ppm	Nitrates as N, ppm	PO_4--- ppm	Color, ppm	Turbidity ppm	pH	Total Alkalinity, ppm
(Mile 417 (Cont'd.) 1/4 pt. Left Bank	Number		3	2	3	3								
	Mean			0.5	5.8	29.3	75							
	Maximum		4,300	0.6	5.9	30	78							
	Minimum		91	0.3	5.7	29	74							
Mile 416 C	Number	3	3	2	3	3		2	2	2	2	2	2	2
	Mean	238		0.6	5.9	30	78	10	0.022	0.020	7.5			36.5
	Maximum	266	430	0.6	6.1	30	80	10	.030	.020	10	< 25	6.9	38
	Minimum	190	150	0.5	5.8	30	76	10	.015	.020	5	< 25	6.9	35
Mile 415 1/4 pt. Right Bank	Number		3	2	3	3								
	Mean			0.9	5.9	30	78							
	Maximum		240,000	1.2	6.3	30	82							
	Minimum		39,000	0.5	5.7	30	76							
C	Number	4	4	2	4	4		2	2	2	2	2	2	2
	Mean	229		0.6	6.1	30	80	12	.022	.020	10			33.5
	Maximum	266	93,000	0.8	6.3	31	84	13	.030	.030	10	< 25	6.9	34
	Minimum	190	20,000	0.3	5.8	30	76	11	.020	.010	10	< 25	6.9	33
1/4 pt. Left Bank	Number		3	2	3	3								
	Mean			0.7	6.0	30	78							
	Maximum		93,000	0.9	6.3	31	82							
	Minimum		23,000	0.4	5.8	30	76							
Mile 414 1/4 pt. Right Bank	Number		2	1	2	2								
	Mean			0.8	5.5	30	72							
	Maximum		430,000		5.7	30	75							
	Minimum		240,000		5.3	30	69							

C - Centerline

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 3 of 3)

Table D-2 - Summary of Individual Results, Sanitary Examination - Ouachita R., Miles 418.5 - 400.0

Station	Samples	Flow, cfs, at Arkadelphia, Ark.	Coliforms MPN per 100 ml	5-day B.O.D. 20°C, ppm	D.O. ppm	Temperature, °C	Per cent Saturation	Cl^- ppm	Nitrates as N, ppm	PO_4^{---} ppm	Color, ppm	Turbidity ppm	pH	Total Alkalinity, ppm
Mile 414(Cont'd) C	Number	2	2	1	2	2								
	Mean	228		1.0	5.6	30	75							
	Maximum	266	240,000		5.7	30	75							
	Minimum	190	75,000		5.5	30	74							
1/4pt. Left Bank	Number		2	1	2	2								
	Mean			0.7	5.7	30	75							
	Maximum		93,000		5.7	30	75							
	Minimum		75,000		5.7	30	74							
Mile 413 C	Number	2	1	1	2	2		2	2	2	2	2	2	2
	Mean	208		0.6	6.4	31	85	10	0.020	0.050	15			35
	Maximum	214			6.7	31	89	11	.020	.080	15	< 25	6.9	35
	Minimum	202	150,000		6.0	31	80	10	.020	.020	15	< 25	6.9	35
Mile 410 C	Number	2	1	1	2	2								
	Mean	208		0.7	6.8	31	90							
	Maximum	214			6.8	31	90							
	Minimum	202	93,000		6.7	31	89							
Mile 407 C	Number	2		1	2	2								
	Mean	208		1.0	6.4	31	85							
	Maximum	214			6.8	31	90							
	Minimum	202			6.0	31	80							
Mile 404 C	Number	2			2	2		1	1	1	1	1	1	1
	Mean	208			7.8	32	106	10	.020	.020	10	< 25	6.9	33
	Maximum	214			7.9	32	107							
	Minimum	202			7.7	32	105							
Mile 400 C	Number	2		1	2	2		2	2	2	2	2	2	2
	Mean	208		0.3	8.1	32	109	10	.025	.025	15			33
	Maximum	214			8.3	32	112	10	.030	.030	15	< 25	6.9	34
	Minimum	202			7.8	32	106	9	.020	.020	15	< 25	6.9	32

C - Centerline

Table D-5 - BOTTOM ORGANISMS - OUACHITA RIVER IN ARKANSAS (ARKADELPHIA TO NIX'S FERRY). Collected August, 1952.

Station	Insects	Mollusca	Annelida	Remarks
Mile 416 above Hwy. 7 bridge	Diptera Chironomidae - numerous Coleoptera Elmidae - one			Sand and gravel bottom
Mile 415.5 - Arkadelphia - below #1 sewer outfall			Annelida numerous	Clay and gravel bottom
Mile 415 - Arkadelphia - below #2 sewer outfall			Annelida numerous	Soft bottom
Mile 414	Ephimerida - few Diptera Chironomidae - numerous Family (?) - one			Diatoms and green filamentous algae - gravel bottom
Mile 412	Trichoptera 3 genera - very numerous Ephimerida - numerous Coleoptera Elmidae - numerous Gyrinidae - numerous Hydrophilidae - one Hemiptera Corixidae - numerous Diptera Chironomidae - very numerous Plecoptera - numerous			Rock and gravel bottom - rapid flowing water - green algae abundant
Mile 400 - at Richeson Ferry	Diptera Chironomidae - few Coleoptera Dytiscidae - few Hydrophilidae - few Trichoptera - few			Gravel and mud
Mile 380 at Nix's Ferry	Diptera Chironomidae - few	Clams, few		Soft bottom with leaves and sticks - Spirogyra and other green algae collected

D.O., 5-day BOD at 20° C., temperature, per cent saturation, chlorides as Cl, nitrates as N, phosphates as PO_4, turbidity, color, pH, and total alkalinity are tabulated by stations. The individual results of the sanitary analyses are presented in Table D3 in the appendix.

Figure D2, is a presentation of the data obtained from the bacteriological analyses. A graphical representation of the D.O. and the 5-day BOD at 20° C. results is presented in Figure D3.

Hydrologic Data - Flow data for the various sampling points on the days sampled are summarized in Table D2; the average daily flows for each station are presented in Table D3 in the appendix. Figure D4 is a hydrograph of the Ouachita River at Arkadelphia covering the period of this survey; the individual flows for this hydrograph are tabulated in Table D4 in the appendix.

Biological - The data obtained during the biological phase of this survey are tabulated in table D5.

Discussion

Water Quality

Coliform Densities, MPN - Figure D2 is a presentation of the results of the bacteriological tests made in this area. Although the number of samples which this graph represents is small, the trend is indicated. The centerline coliform MPN values, above the outfalls, remain at a fairly low level, the MPN values between miles 418.0 and 416.0 ranging between 150/100 ml to 1500/100 ml; however, the coliform MPN values immediately below the outfalls are decidedly greater due to the addition of Arkadelphia's sewage. The coliform MPN values found in the river for the quarter point samples taken nearest the right bank (looking downstream) reach a maximum concentration of 430,000/100 ml. They are generally higher than the values from the other cross-section sampling point as would be expected since the sewage from Arkadelphia enters the river from the right bank. All values found during the survey were above the average values recommended for public water supply sources.*

Dissolved Oxygen (D.O.) - Referring to Figure D3, there is no clearly defined oxygen sag below Arkadelphia's sewage outfalls. The lowest mean D.O. value from the centerline samples was obtained at mile 414.0 and amounted to 5.6 ppm or 75% of saturation; the minimum D.O. at this point was 5.5 ppm or 74% of saturation. The D.O. in the river increases steadily below this point, reaching a mean D.O. of 8.1 ppm at mile 400.0, and a minimum of 7.8 ppm (saturations of 109 and 106% respectively). This increase could be due to turbulence, shallow depth (6" in certain sections) or to algae activity.

Five-day BOD at 20°C. - The mean centerline 5-day BOD values obtained during the survey were low, ranging from 0.3 to 1.2 ppm. An analysis of the data indicates that there was no measurable increase in the BOD concentration of the river resulting from the discharge of Arkadelphia's sewage. The volume of water in the stream afforded a dilution ratio of approximately 260 to 1 which accounts for the low values.

Temperature - During the period of the survey, the temperature of the river at the various sampling points ranged between 29° C. and 32° C., the higher temperature occurring downstream. This increase in water temperature at points further downstream was probably due to the increase in air temperature during the day. Temperatures at stations farther downstream were taken later in the day.

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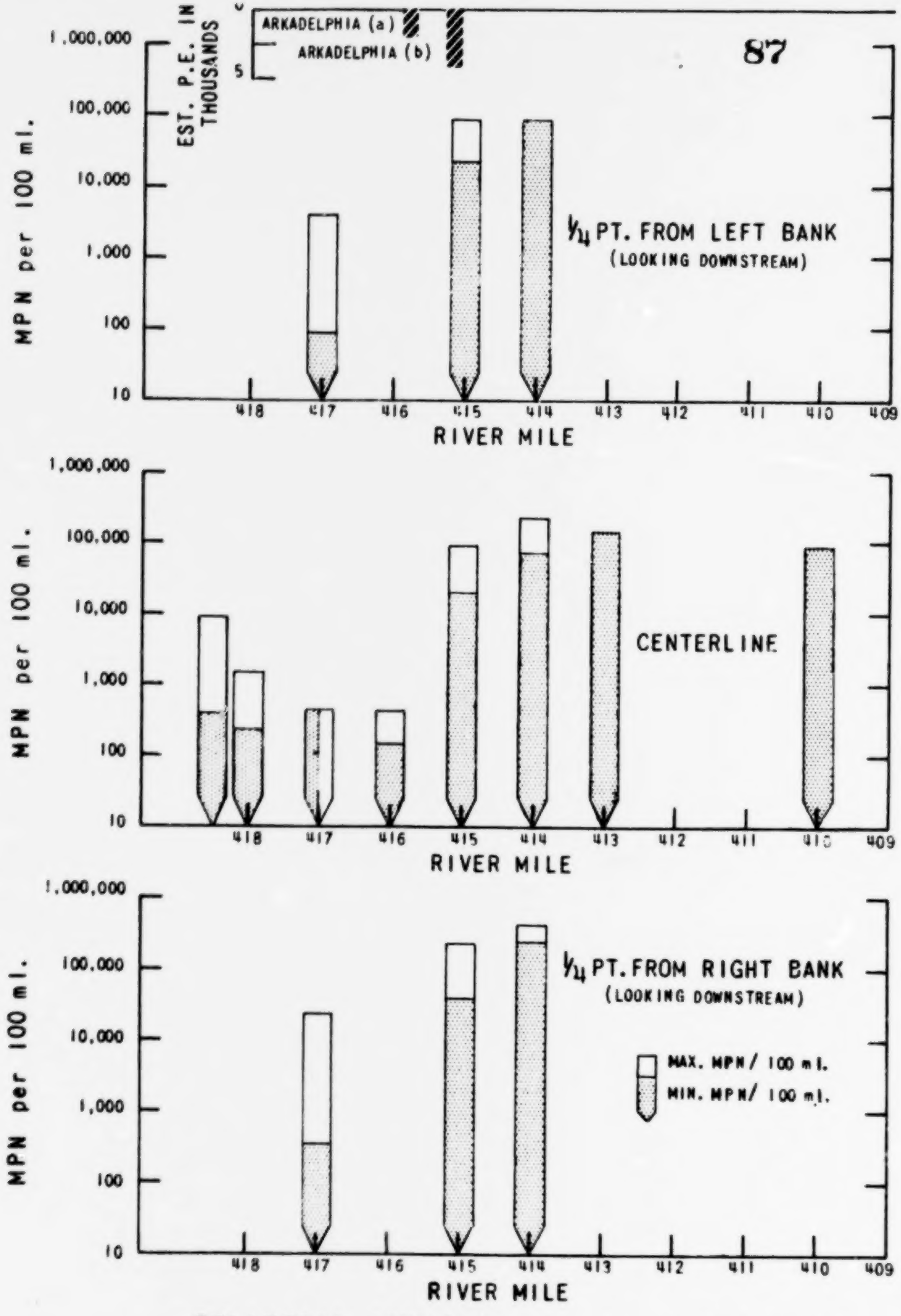
* Public Health Bulletin No. 296, "Manual of Recommended Water-Sanitation Practice," recommended by the U. S. Public Health Service, 1946.

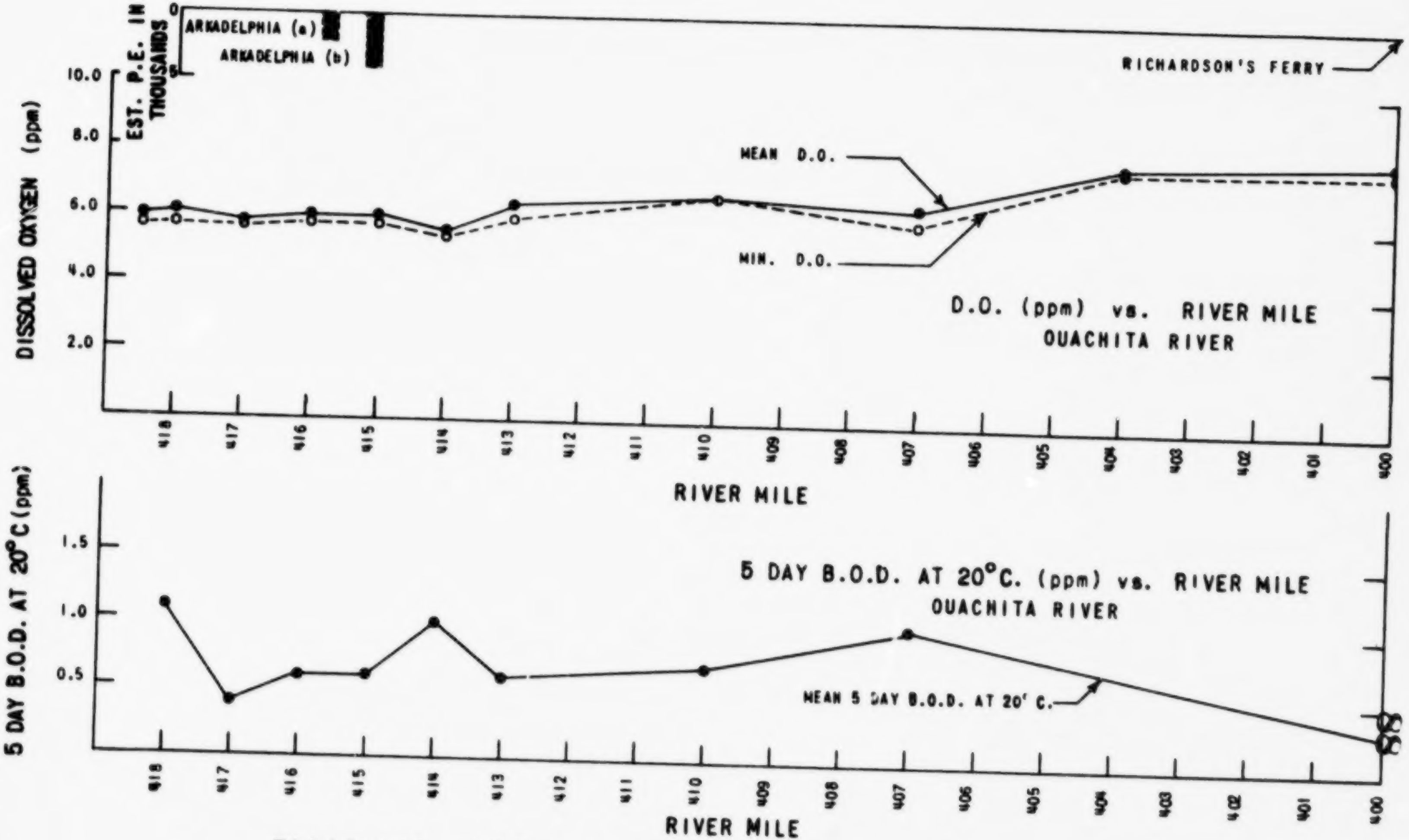


COLIFORM MPN/100 ml. vs. RIVER MILE

OUACHITA RIVER

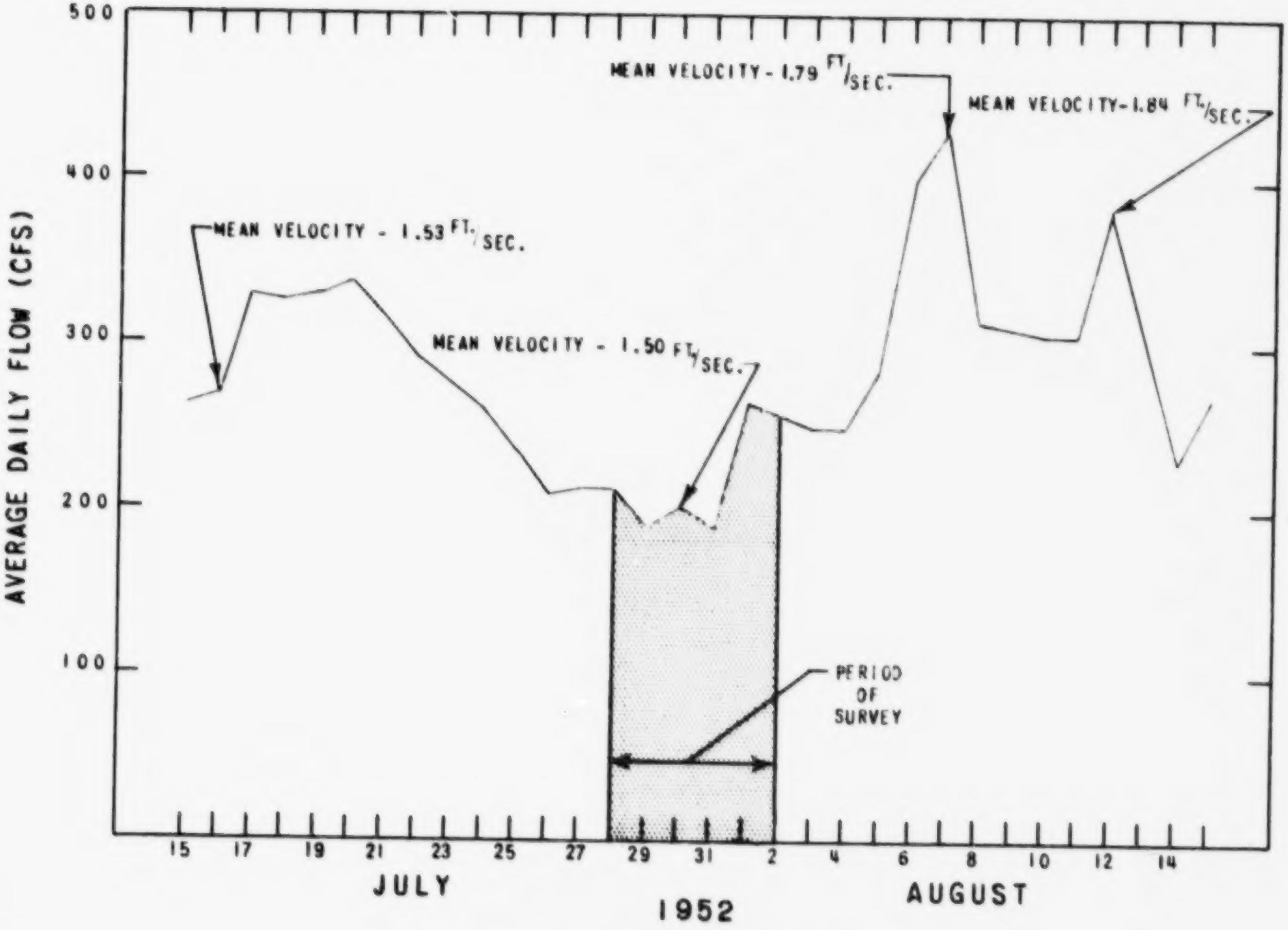
JULY 28, 1952 TO AUGUST 2, 1952

FIGURE D - 2



DISSOLVED OXYGEN & 5 DAY B.O.D. AT 20°C. vs. RIVER MILE
OUACHITA RIVER
(JULY 28 TO AUGUST 2, 1952)

FIGURE D-3



HYDROGRAPH
OUACHITA RIVER
ARKADELPHIA, ARKANSAS

FIGURE D-4

Chlorides (Cl) - The chloride content of the Ouachita River in this area remained fairly constant for all stations, ranging from 8 ppm to 13 ppm, the overall average being approximately 10 ppm. Water containing chloride concentrations in this range are satisfactory for practically all uses.

Nitrate as N - The range in nitrate concentrations for all the stations was between 0.013 and 0.040 ppm, averaging 0.021 ppm. Though these values are relatively small they may be large enough to stimulate algae growth.

Phosphate (PO_4) - The phosphate content of the water samples ranged between 0.010 ppm and 0.090 ppm, averaging 0.035 ppm. Though relatively small, these concentrations of phosphate may supply enough nutrient to stimulate algae growth.

Turbidity - There was very little turbidity in the river in this area; all of the samples had a turbidity value of less than 25 ppm.

Color - The Ouachita River in this area is very low in color. The average color concentration of the samples was 12 ppm.

pH - The hydrogen ion concentration of these waters during the survey remained very constant, ranging between a pH of 6.8 and 6.9.

Total Alkalinity - The total alkalinity ranged between 32 ppm and 38 ppm, averaging 34 ppm.

Hydrologic Data - The daily flows of the Ouachita River at Arkadelphia, Ark. averaged 220 cfs for the survey. Flows ranged from 190 to 256 cfs. The average discharge, 220 cfs, is twice the minimum monthly discharge of 113 cfs, which was the minimum recorded for 22 years of record. (See Table D4)

Biological - A biological investigation of the river between Arkadelphia and Nix's Ferry was conducted to determine the types and relative abundance of bottom organisms inhabiting this reach of stream and to determine the extent, if any, to which sewage from Arkadelphia affects the bottom fauna. A listing of the types of organisms collected from the various stations and their relative abundance is given in Table D5.

Above Arkadelphia at mile 416, numerous midge larvae and a single beetle larva were collected from the sand and gravel bottom. There were no rocks in the general area from which other insects might have been collected.

Below the first station the stream consisted of a fairly deep, long pool of slowly moving water into which Arkadelphia sewage was discharged from two sewer outfalls. Below the first, or upstream, sewer outfall, annelids (Tubifex) in large numbers were the only bottom organisms found. The same condition existed below the second outfall where annelids only were found.

About one mile farther downstream where the stream became more shallow and water flowed over a gravel and sand bottom, numerous midge and a few mayfly larvae were collected. The collection of mayfly larvae is significant as it indicates that oxygen was present in the water at this point in sufficient amounts to maintain a favorable environment. Filamentous green algae and diatoms were rather abundant in this area.

About three to four miles below the sewer outfalls, the stream narrowed considerably and flowed rapidly over rock and gravel bottom. This environment provided shelter for organisms and aerated the water. Sewage carried in the water provided an ample food supply and stimulated the growth of a large variety of organisms. Caddis flies, mayflies, beetles, true bugs, midges and stoneflies were all found, most of them in very large numbers.

The next station was located at mile 400 (Richardson's Ferry), about 12 miles downstream. The water at this station was fairly deep and moving slowly; the bottom was mostly gravel with some mud deposits. Midges, beetles and caddis fly larvae were found at this station, though not in great numbers. Farther downstream at mile 380 (Nix's Ferry) midge larvae and a few clams were collected. The river bottom at this point consisted of soft mud near the shore with leaves, sticks and other vegetation imbedded in it. The stream was flowing gently, and near the shore spirogyra and other green algae were fairly abundant.

Bottom samples collected from the reach of the river between Arkadelphia and Nix's Ferry contained relatively few organisms where the river was deep and the current slow. Near Arkadelphia, below the sewer outfalls, there were numerous annelids (Tubifex), undoubtedly because of the food provided by sewage. Below Arkadelphia, in a swiftly moving section of the stream, a very great increase in bottom organisms is attributed to the food supplied to the organisms, either directly or indirectly from the sewage and a favorable habitat provided by the swift flow of water over rocks. The over-all effect of sewage from Arkadelphia on biological life is the stimulation of growth organisms.

PART E

OUACHITA RIVER

CAMDEN, ARK. TO COLUMBIA, LA.

MILE 351 TO MILE 133

AUGUST 5, 1952 TO SEPTEMBER 10, 1952

Part E

Ouachita River - Camden, Ark. to Columbia, La.

Mile 351 to Mile 133

Summary

Chemical and Bacteriological - "Oxygen sags" occurred in the Ouachita River below its junction with West Two Bayou (mile 346) and Black Bayou (mile 178.6). These oxygen sags are caused by the discharge of wastes from the International Paper Company mill to West Two Bayou, and from the Brown Paper Mill Company, Inc., to Black Bayou. Minimum dissolved oxygen values of 1.6 ppm and 0 ppm occurred in the Ouachita below its junction with West Two Bayou and Black Bayou, respectively.

In the impoundment caused by Lock and Dam No. 8 (mile 297.5) brine stratification extended for 17 miles upstream from the dam. No brine stratification occurred on the downstream side of the dam. Chloride values varied from 43 ppm at the surface to as high as 7,410 ppm at the bottom of the river.

Coliform densities increased below Camden, Ark. (mile 345), Saline River (mile 251), Sterlington, La. (mile 206.7) and East and West Monroe (mile 179). The highest median coliform MPN/100 ml value (43,000) occurred below Monroe, La.

Biological - The Ouachita River between Camden, Arkansas, and Columbia, La., was, at the time of the survey, a slowly moving body of water and was held at a fairly uniform level by a system of locks and dams. Bottom samples were generally obtained from soft bottom near the edges of the river. The bottom at certain places, however, was composed of fine sand or clay.

At no place in this section of the river was a large variety of organisms found. Predominate organisms consisted of midges (chironomids), snails and annelid worms. These are facultative organisms that tolerate moderate amounts of pollution and require a fairly large amount of organic detritus in which to live. The abundance of these organisms in the river generally increased below sources of pollution. Snails were particularly abundant between miles 337 and 318 (between West Two Bayou and Galion, Arkansas), mile 224 (Alabama Landing), mile 208 (above Sterlington), mile 175 (below Monroe) and mile 153 (below Monroe). Midge larvae were collected in fairly large numbers all along the Ouachita but were particularly numerous below Monroe at mile 175. Annelids were especially numerous in the bottom and at miles 337 and 318 (below West Two Bayou), at mile 236 (below Mossy Lake) and at stations located between Lock No. 4 and Columbia, La.

Effect of Removal of Lock and Dams - The proposed removal of the locks and dams on the Ouachita River would affect the river adversely with regard to navigation and recreation and would benefit its water quality by better chloride mixing and by increasing the dissolved oxygen content. The dissolved oxygen increase will result from increased aeration rate due to increased stream velocity.

Navigation - A series of ponds followed by shoal areas will probably develop upstream as far as mile 351 when the locks and dams are removed. The conditions would probably be similar to those presently existing at Arkadelphia, Arkansas (See part D). However, the velocities would be lower than those at Arkadelphia. The river would be navigable only during times of high flow.

Chloride Concentration - At the time of this survey, brine stratification was found behind lock and dam No. 8. Such a condition would not exist when these locks and dams are removed. Instead of the gradual rising and falling of chloride concentrations observed in the downstream portions of the stream, sharp "slug" concentrations will probably be observed when brine flushouts occur.

Dissolved Oxygen - During this survey, two stretches of oxygen sag were found, one below West Two Bayou, Arkansas (International Paper Company) and one below Black Bayou, Louisiana (Brown Paper Mill Co.). Large sludge banks were observed below both of these tributaries. The removal of the locks and dams, although increasing the low flow velocities observed during the survey, will probably not be of the magnitude necessary to prevent sludge bank formation below raw waste discharge points. The sludge banks will probably be extended further downstream.

The removal of the locks and dams will increase reaeration of the streams because of greater stream velocity and less depth of flow. The increased velocity and attendant better reaeration will decrease the magnitude of the oxygen depletions and the minimum point of the oxygen sag will be shifted downstream.

Introduction

The survey was conducted to (1) determine the sanitary quality of the Ouachita River, and (2) locate and define, if possible, any oxygen sags in this area, and (3) predict the effects of the proposed removal of the locks and dams in the Ouachita River.

Description

General - The Ouachita River between Camden, Ark., and Columbia, La., a distance of 218 miles, flows in a general southerly direction. Stream slopes in this area are between 2 to 3 feet per mile. The adjacent land has gentle rolling characteristics. The area drained by the Ouachita River above Monroe, La. (which is 170 miles downstream from Camden, Ark.) amounts to 15,400 square miles.

The main tributaries to the Ouachita River in this area are, East and West Two Bayou, Smackover Creek, Moro Creek, and the Saline River in Arkansas, Bayou Bartholomew, Bayou de L'outre, Bayou D'Arbonne, and Black Bayou in Louisiana.

Economic Background - Extensive oil fields exist in the southwestern part of Arkansas and the northern part of Louisiana. Manufacturing developments are those associated with the processing of petroleum, lumber, bauxite ores and cotton, production of naval ordnance materials and chemical solvents. The three pulp and paper mills in this area, those at Cullendale and Crossett in Arkansas, and that at Monroe, Louisiana, produce about 500 tons of paper daily. Much of the lumber and pulpwood used in lumber production and the manufacture of paper, comes from within this basin. Livestock are an important phase of the agricultural activities of the area.

Water Uses

Public Water Supplies - Camden, Arkansas, obtains its water supply from the Ouachita River, while the city of Monroe, La., uses Bayou de Saird as its source. The towns of Cullendale, Smackover, Crossett, Huttig and El Dorado, in Arkansas, Bastrop, Sterlington, West Monroe, and Columbia in Louisiana, all obtain their water supply from wells.

Navigation - Locks and dams on the Ouachita River maintain a minimum depth necessary for navigation from the mouth of the river to above Camden, Ark., a distance of 350 miles. Figure E-1, shows the location of these various locks and dams, and figure E-2 the elevations of water levels maintained.

Fishing - Considerable commercial fishing is done in the Ouachita River in this area. Although a commercial plant for the converting of gar into fertilizer has been constructed in this area, little gar fishing was in progress during the survey. Gar were very much in evidence, however. There are many small fishing villages near the Arkansas-Louisiana state line, catering to both resident and non resident fishermen.

Recreational - The Ouachita is used extensively for boating from Camden to Columbia (and downstream). Boating is an especially popular recreational activity at Monroe, La.

Sources of Pollution

Domestic Pollution - A tabulation of the various communities as to the population served by sewers, and the estimated population equivalent discharged into the streams is presented in Table E-1. This table shows that Camden, Ark., and Monroe and West Monroe, La., discharge the major portion of domestic sewage directly into the Ouachita River.

Industrial Pollution - No estimates are presented for the pollution loadings of the various manufacturing and producing activities in this area. The most reliable data available on the pulp and paper mill plants were obtained from Lockwoods Directory of the Paper and Allied Trades, 1952. This volume lists the pulp production of the three plants in this area — The International Paper Company plants at Cullendale, Ark., produces 540 tons of pulp per day, while the Crossett Paper Mill, at Crossett, Ark., produces 375 tons per day. Both of these plants are of the unbleached sulfate fibre class, and both discharge their wastes into lagoons for treatment before discharging the effluent into the Ouachita River. At West Monroe, La., the Brown Paper Mill Company, Inc., of the unbleached sulfate fibre class, produces 550 tons of pulp per day, and discharges its wastes into Black Bayou.

Survey Methods

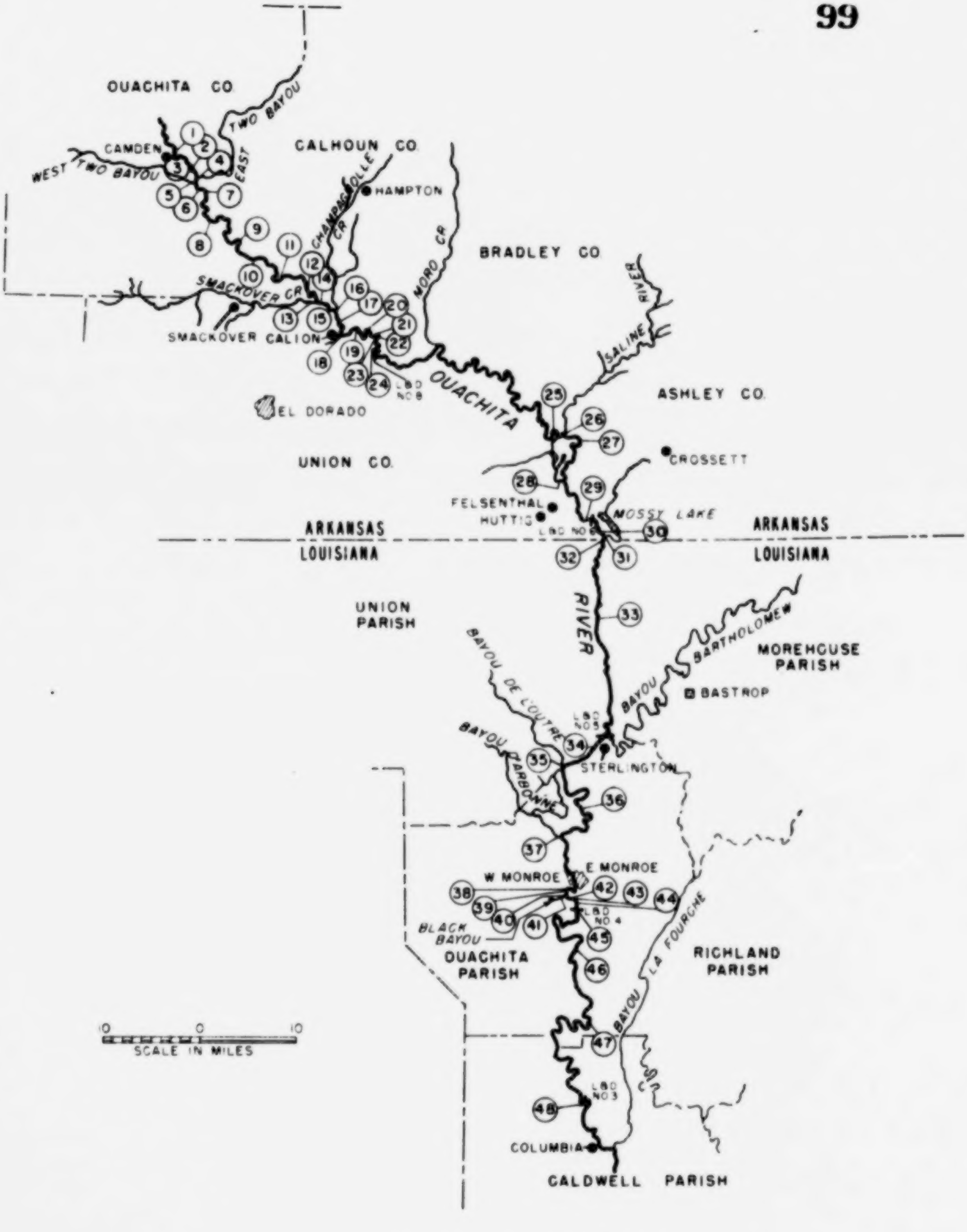
Location of Sampling Stations - Whenever possible, bridges were used as sampling points. However, the greater portion of the sampling was done by boat; the conditions of the river in pool stages made this type of sampling relatively easy. Plate E-1 shows the location of the various sampling stations on the Ouachita River. Table E-2 lists these stations showing river mileage location, description, and the number of times sampled.

Normal Sampling Procedures - A standard copper, one-gallon capacity, 3-bottle sampler was used for sampling. All of the samples for complete analysis, and most of those for partial analysis were taken at midstream. The channel, in most cases was midstream, due to the pooled conditions. Except for special profile studies, samples were taken at a three foot depth.

Special Sampling Procedures

Brine Stratification Studies - During this phase of the survey, quarter point samples were taken immediately below possible sources of the chlorides. Centerline profiles were made between mile 351 and mile 933, to determine where stratification and mixing were occurring.

Oxygen Sag Studies - Below West Two Bayou, which carries the wastes from the International Paper Company plant at Cullendale, Arkansas, samples for dissolved oxygen were taken at three foot depths at intervals of a few miles, to locate sections of oxygen depletion. The distance between sampling points was short because the low flow conditions existing at the time caused low


OUACHITA CO.
CALHOUN CO.
BRADLEY CO.
ASHLEY CO.
UNION CO.
CAMDEN
HAMPTON
WEST TWO BAYOU
EAST TWO BAYOU
CHAMPAGNOLLE CR
MORO CR
SMACKOVER CR
SMACKOVER
CALION
EL DORADO
L&D NO 8
OUACHITA
SALINE RIVER
CROSSETT
FELSENTHAL
HUTTIG
MOSSY LAKE
L&D NO 6
ARKANSAS
LOUISIANA
UNION PARISH
RIVER
BAYOU DE L'OUTRE
BAYOU BARTHOLOMEW
MOREHOUSE PARISH
BASTROP
L&D NO 5
BAYOU DARBONNE
STERLINGTON
W MONROE
E MONROE
BLACK BAYOU
L&D NO 4
OUACHITA PARISH
RICHLAND PARISH
BAYOU LA FOURCHE
L&D NO 3
COLUMBIA
CALDWELL PARISH
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
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34
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37
38
39
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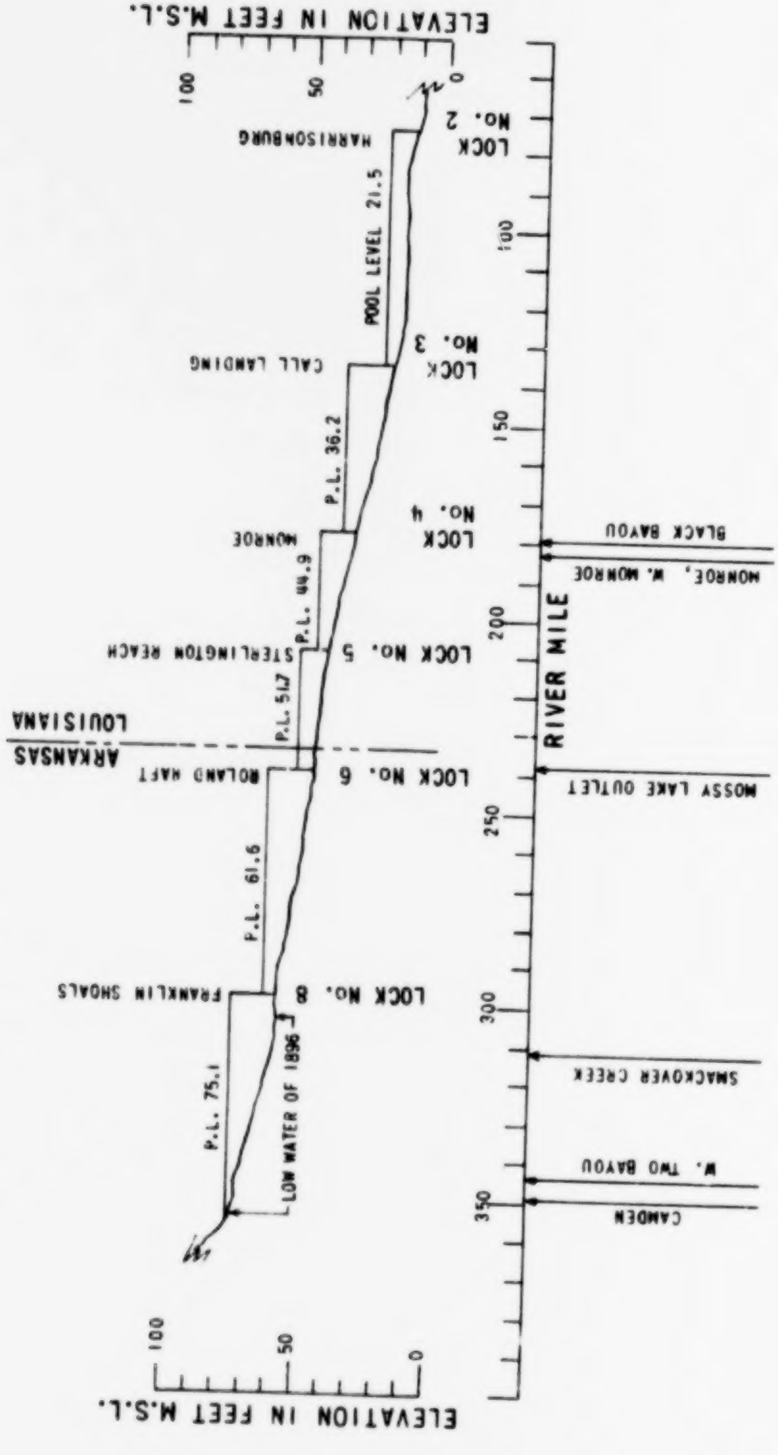
41
42
43
44
45
46
47
48
10 0 10
SCALE IN MILES

SAMPLING STATIONS
OUACHITA RIVER

FIGURE E-1



PROFILE
LOW WATER AND POOLS
OUACHITA RIVER

FIGURE E-2

Table B-1 - Domestic Sources of Pollution
Ouachita River, Mile 351 to Mile 133.0

Watercourse & Municipality	River Mile	Estimated Population Served By Sewers	Treatment	Estimated Population Equivalent Discharged to Watercourse
Ouachita River				
Camden (a)	350 to	3,500	Primary	2,500
(b)	348	6,000	None	6,000
East Two Bayou	343.8			
Bearden		1,000	Primary	700
West Two Bayou	343.6			
Cullendale				
Smackover Cr.	311			
Stephens		800	Primary	550
Smackover		2,000	None	2,000
Champagnolle Cr.	308.5			
Hampton		800	None	800
Saline River	254			
Bayou Bartholomew	209			
Paper Mill Ditch				
Bastrop		9,000	Primary	6,300
Sterlington	209-206			
Bayou de Loutre	203			
Bayou D'Arbonne	188			
Monroe	184-176	25,300	None	8,000*
W. Monroe	184-179	9,800	None	9,800
Black Bayou	178.5			

* Estimated 70 per cent discharged to Bayou Lafourche.

(1 of 3)

Table E-2 - Sampling Stations, Ouachita River, Camden, Arkansas, to Columbia, Louisiana

Sampling Station	River Mile	Description	Days Sampled
1	351	U.S. 79 Highway Bridge	8
2	345	Bradley Ferry Landing	5
3	344	0.4 miles above East Two Bayou	1
4		East Two Bayou (junction with Ouachita - mile 343.6)	4
5		West Two Bayou (junction with Ouachita - mile 343.3)	5
6	342.5	McMahons Landing	1
7	341	Piles Landing	4
8	336	Frenchport Landing	5
9	330	Starvation Point Landing	1
10	325	0.5 miles below New Port Landing	2
11	319	0.4 miles above Millers Bluff Landing	3
12	313	Burnham Landing	2
13		Smackover Creek (junction with Ouachita River - mile 311)	2
14	310	1 mile below Smackover Creek	1
15	309	2 miles below Smackover Creek	1
16		Champagnolle Creek (junction with Ouachita River - mile 308.7)	1
17	308	U. S. 167 Highway Bridge	8
18		Chapelle Slough (Junction with Ouachita River - mile 307)	1
19	305		2

Table E-2 - Sampling Stations, Ouachita River, Camden, Arkansas, to Columbia, Louisiana (continued)

Sampling Station	River Mile	Description	Days Sampled
20	303.5		1
21	301	1/4 mile above dock at Stick Bend	1
22	299	1/8 mile below Ginhouse Bend	1
23	298	1/4 mile below Yellow Bluff Bend	1
24	297.6	100 yards above Lock and Dam No.8	1
25	256		1
26		Saline River (junction with Ouachita River - mile 254)	1
27	251	U. S. 82 Highway Bridge	8
28		LaPille Creek (junction with Ouachita River - mile 244.5)	1
29	238	100 yards above Lock and Dam No.6	1
30	237.5	1/2 mile below Lock and Dam No.6	5
31		Outlet from Mossy Lake (junction with Ouachita River - mile 237)	5
32	235.5	Arkansas-Louisiana State Line	10
33	224.5	Alabama Landing	5
34	206.7	U. S. 167 Highway Bridge	5
35		Bayou de L'Outre (junction with Ouachita River - mile 203)	6
36	195	1 mile above Whites Landing	7
37		Bayou D'Arbonne (junction with Ouachita River - mile 188.5)	6
38	179.1	at Brownville Dock, 0.45 miles above Black Bayou	11

Table E-2 - Sampling Stations, Ouachita River, Camden, Arkansas, to Columbia, Louisiana (continued)

Sampling Station	River Mile	Description	Days Sampled
39	178.8	0.15 miles above Black Bayou	1
40	178.7	0.05 miles above Black Bayou	2
41		Black Bayou (junction with Ouachita River - mile 178.65)	7
42	178.6	0.05 miles below Black Bayou	3
43	178	0.65 miles below Black Bayou	3
44	177.6	1.05 miles below Black Bayou	2
45	177.35	100 yards above Lock and Dam No.4	9
46	165	Roselawn Landing	5
47	153.5	Lower Bosco Landing	5
48	133	100 yards above Lock and Dam No.3	5

stream velocities. Routine sampling failed to show any considerable depletion of oxygen below Mossy Lake outlet which carries the lagoon treated wastes from the Crossett Paper Mill; hence, no extensive oxygen profiles were run in this area. Below Black Bayou, La., which carries the Brown Paper Mill Company wastes, a series of vertical dissolved oxygen profiles were run.

Whenever a sample was taken, time, temperature (to the nearest degree centigrade), and any descriptive remarks that would explain special conditions, were recorded on standard field sheets.

Presentation of Data

Water Quality - One thousand, eight hundred and forty-eight chemical and physical determinations were performed on 415 samples; 129 samples were taken for bacteriological analysis. The results of the chemical, physical and bacteriological tests are summarized in Table E-3; maximum, minimum, and mean values for dissolved oxygen, 5-day BOD at 20°C., temperature, per cent saturation, chloride (Cl^-), nitrate as N, phosphate (PO_4), turbidity, color, pH and total alkalinity are tabulated by stations. A median value is given instead of a mean for the coliform M.P.N. results. Data are presented in Table E-4 in the appendix.

Figure E-3 is a graphical representation of the mean and minimum dissolved oxygen values, and the mean and maximum 5-day BOD at 20°C. values for the various sampling points. The data obtained for coliform densities as MPN, are shown in Figure E-4.

Special Studies

Brine Stratification - The data obtained during this phase of the survey are tabulated in Table E-4 in the appendix. Figure E-5 is a diagramatic representation of the stratification of chlorides behind Lock & Dam No.8 (mile

297.5). The top and bottom chloride concentrations are plotted against river miles in figure E-6. A plot of chloride concentrations against time for different sampling points is presented in Figure E-7.

Oxygen Study Below Cullendale, Arkansas - (International Paper Company Plant). The data obtained in this study are presented in Table E-4 in the appendix, and summarized in Table E-3. The results of this study have been plotted in Figure E-3, along with other data on dissolved oxygen obtained in the survey.

Oxygen Study Below Black Bayou, Louisiana - (Brown Paper Mill Company). Table E-3 and appendix Table E-4, list the summary and complete tabulation, respectively, for this study. A series of verticle dissolved oxygen profiles were run in this section of the river. The data obtained in two of the series are plotted by stations in figure E-8.

Hydrologic Data - Tables E-3 and E-4 contain the summary and complete tabulations of recorded flows for the individual stations on the days sampled. Figure E-9 is a hydrograph for the Ouachita River of the flows during the survey period as reported at Camden, Arkansas, and at Monroe, Louisiana, and which are tabulated in Tables E-5 and E-6.

Figure E-10 is a frequency plot of an analysis of flow data for the Ouachita River at Monroe, Louisiana, between the years 1939-1950.

Temperature Data - The results of an analysis made on average daily water temperature data for periods of June to October for the Ouachita River at Camden, Arkansas during the period, October 1946 to September 1948, are presented in figure E-11.

Biological - Data collected during the biological phase of this survey are tab-

ARKANSAS-WHITE-RED FIELD STUDIES

(Sheet 1 of 8)

Table E-3 - Individual Results, Sanitary Examination, Ouachita River, Miles 351.0 to 133.0

Summary

Station	Samples	Ave.Daily Flow CFS	5-Day B.O.D. 20°C, ppm	D.O. ppm	Temper-ature, °C.	Per Cent Saturation	Cl⁻ (a) ppm	Nitrates as N, ppm	PO_4 ppm	Color ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml.
Mile 351 C	No.samples		7	7	7	7	8	6	7	7	7	7	7	7
	Mean	828	0.6	6.5	30	86	21	0.018		22			26	1,500*
	Max.	1150	1.3	6.9	31	92	41	0.030	0.070	25	42	7.0	28	110,000
	Min.	690	0.2	6.1	29	80	9	0.010	<0.002	20	<25	6.7	21	430
Mile 345 C	No.samples		5	5	5	5	5	2	3	3	3	3	3	3
	Mean		0.4	6.2	30	81	29	0.010	0.060	22			26	24,000*
	Max.		0.6	6.8	32	89	61	0.012	0.140	25	112	6.8	29	24,000
	Min.		0.1	6.0	28	77	11	0.008	0.010	20	<25	6.6	25	7,500
Mile 344 C	No.samples		1	1	1	1	1	1	1	1	1	1	1	1
	Value		0.4	5.9	29	76.1	20	0.010	0.180	15	50	6.7	24	9,300
East Two Bayou C	No.samples		4	4	4	4	4	1	4	4	4	4	4	4
	Mean		0.5	6.3	30	83	31	0.350		24			31	8,400*
	Max.		0.7	6.7	31	88	50		0.080	30	40	6.9	37	24,000
	Min.		0.3	6.0	29	78	10		<0.002	20	<25	6.7	24	4,300
West Two Bayou C	No.samples		5	5	5	5	5	3	5	5	5	5	5	5
	Mean		82	0	33	0	71	5.670		210	226		168	2,900*
	Max.		92	0	36	0	123	8.000	2.000	375	380	7.3	230	9,300
	Min.		74	0	30	0	34	2.000	<0.002	75	125	6.7	95	<360
Mile 342.5 C	No.samples		1	1	1	1								
	Value		2.2	4.0	29	51								

C = Centerline. All values at 3 ft. depth. (a) See Table E-4 for vertical cross-section values. *Median.

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 2 of 8)

Table E-3 - Individual Results, Sanitary Examination, Ouachita River, Miles 351.0 to 133.0
Summary

Station	Samples	Ave. Daily Flow CFS	5-day B.O.D. 20°C, ppm	D.O. ppm	Temper- ature, °C.	Per Cent Saturation	Cl⁻ (a) ppm	Nitrates as N, ppm	PO_4 ppm	Color ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml.
Mile 341	No. samples		3	4	4	4	4	2	3	3	3	3	3	3
C	Mean		1.9	4.2	30	55	34	0.016	0.020	28	29		31	9,300*
	Max.		2.4	4.6	30	60	52	0.020	0.026	35	30	6.8	32	43,000
	Min.		1.3	3.8	29	49	11	0.012	0.014	25	28	6.8	28	2,300
Mile 336	No. samples		5	5	5	5	5	4	4	4	4	4	4	4
C	Mean		2.0	3.7	30	48	24	0.023	0.008	28	30		32	1,615*
	Max.		3.3	4.4	32	59	37	0.050	0.016	35	32	6.9	35	2,300
	Min.		0.9	1.6	30	21	15	0.012	0.006	25	27	6.8	28	750
Mile 330	No. samples		1	1	1	1	1	1	1	1	1	1	1	1
C	Value		0.7	4.0	30	53	11	0.015	0.004	25	26	6.8	30	930
Mile 325	No. samples		2	2	2	2	2	2	2	2	2	2	2	2
C	Mean		1.0	3.8	30	50	19	0.025	0.035	28			30	
	Max.		1.5	3.9	30	51	28	0.030	0.060	30	25	6.9	33	150
	Min.		0.5	3.6	30	48	10	0.020	0.010	25	<25	6.8	26	91
Mile 319	No. samples		2	3	3	3	3	1	3	3	3	3	3	3
C	Mean		1.0	3.9	31	52	19	0.025	0.027	27			32	91
	Max.		1.4	5.1	32	69	20		0.040	30	<25	7.0	38	280
	Min.		0.7	3.1	30	41	18		0.002	25	<25	6.8	27	73
Mile 313	No. samples			2	2	2	2							
C	Mean			4.5	32	61	17							
	Max.			4.6	32	63	17							
	Min.			4.3	32	58	17							

C = Centerline. All values at 3 ft. depth. (a) See Table E-4 for vertical cross-section values. *Median.

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 3 of 8)

Table E-3 - Individual Results, Sanitary Examination, Ouachita River, Miles 351.0 to 133.0

Summary

Station	Samples	Ave.Daily Flow CFS	5-day B.O.D. 20°C, ppm	D.O ppm	Temperature, °C.	Per Cent Saturation	Cl^- (a) ppm	Nitrates as N, ppm	PO_4 ppm	Color ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml.
Smackover Ck.	No.samples		2	2	2	2	2	1	2	2	2	2	2	2
C	Mean		0.9	5.0	32	68	38	0.030	0.014	20			30	
	Max.		0.1	5.2	33	72	52		0.026	20	25	6.9	31	2,100
	Min.		0.7	4.8	32	65	24		0.002	20	<25	6.8	29	150
Mile 310	No.samples						1							
C	Value						30							
Mile 309	No.samples			1	1	1	1							
C	Value			4.8	31	64	35							
Champagnolle	No.samples		1	1	1	1	1		1	1	1	1	1	1
Creek	Value		0.6	5.2	31	69	53		0.018	25	<25	6.9	28	36
Mile 308	No.samples		7	7	7	7	8	7	7	7	7	7	7	7
C	Mean		4.0	3.8	30	50	128	0.062		23			37	<360*
	Max.		5.6	4.8	31	63	223	0.200	0.080	30	27	6.9	43	110,000
	Min.		0.4	3.3	29	43	43	0.015	<0.002	15	<25	6.9	33	210
Chapelle	No.samples		1	1	1	1	1							
Slough	Value		1.8	5.4	31	72	155							
Mile 305	No.samples		1	2	2	2	2	1	1	1	1	1	1	1
	Mean		1.6	5.7	32	77	124	0.100	0.030	15			31	
	Max.			5.7	33	78	192							
	Min.			5.7	31	76	55				<25	6.9		430

C = Centerline. All values at 3 ft. depth. (a) See Table E-4 for vertical cross-section values. *Median.

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 4 of 8)

Table E-3 - Individual Results, Sanitary Examination, Ouachita River, Miles 351.0 to 133.0

Summary

Station	Samples	Ave.Daily Flow CFS	5 day B.O.D. 20°C, ppm	D.O. ppm	Temper-ature, °C.	Per Cent Saturation	Cl^- (a) ppm	Nitrates as N, ppm	PO_4 ppm	Color ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml.
Mile 303.5	No.samples			1	1	1	1							
	Value			5.7	31	76	184							
Mile 301	No.samples			1	1	1	1							
	Value			6.0	32	81	197							
Mile 299	No.samples			1	1	1	1							
	Value			5.9	32	79	255							
Mile 298	No.samples		1	1	1	1	1	1	1	1	1	1	1	1
	Value		0.2	5.6	32	76	299	0.100	0.020	15	<25	6.9	37	<36
Mile 297.6	No.samples		1	1	1	1								
	Value		1.0	5.5	33	76								
Mile 255	No.samples			1	1	1	1							
	Value			6.1	32	82	801							
Saline R. C	No.samples		1	1	1	1	1		1	1	1	1	1	1
	Value		0.9	5.7	32	77	188		0.014	15	<25	7.0	36	230
Mile 251 C	No.samples		8	8	8	8	8	7	7	7	7	7	7	7
	Mean		1.2	7.1	31	94	817	0.087		12			34	930*
	Max.		2.2	8.9	32	120	928	0.120	0.040	20	25	7.0	40	15,000
	Min.		0.3	5.5	30	73	415	0.040	<0.002	10	<25	6.9	27	91

C = Centerline. All values at 3 ft. depth. (a) See Table E-4 for vertical cross-section values. *Median.

ARKANSAS-WHITE-RED FIELD STUDIES

Table E-3 - Individual Results, Sanitary Examination, Ouachita River, Miles 351.0 to 133.0 (Sheet 5 of 8)

Summary

Station	Samples	Ave.Daily Flow CFS	5-day B.O.D. 20°C, ppm	D.O. ppm	Temper-ature, °C.	Per Cent Saturation	Cl⁻ (a) ppm	Nitrates as N, ppm	PO₄ ppm	Color ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml.
La Pille Cr. C	No.samples		1	1	1	1	1		1	1	1	1	1	1
	Value		0.94	7.23	31	96	704		<0.002	15	<25	7.0	37	<36
Mile 238.8 C	No.samples		1	1	1	1	1							
	Value		1.51	7.20	32	97	728							
Mile 237.5 C	No.samples		5	5	5	5	5	2	5	5	5	5	5	4
	Mean		1.3	7.5	32	100	850	0.075		10			35	91*
	Max.		2.0	8.1	33	110	901	0.100	0.020	10	<25	6.9	41	390
	Min.		0.7	6.7	30	90	747	0.050	<0.002	10	<25	6.8	25	36
Outlet from Mossy Lake C	No.samples		5	5	5	5	5	2	5	5	5	5	5	5
	Mean		17	0.0	31	0.2	109	6.500		425	106		370	930*
	Max.		24	0.1	33	0.9	130	7.000	0.024	500	130	7.7	385	15,000
	Min.		9.3	0	30	0	97	6.000	<0.002	375	85	7.4	352	430
Mile 235.5 C	No.samples		9	10	10	10	10	7	10	10	10	10	10	10
	Mean		1.5	7.0	31	93	760	0.080		15			39	120*
	Max.		2.3	8.1	32	110	882	0.120	0.020	20	28	7.3	43	930
	Min.		1.0	6.2	28	83	610	0.030	<0.002	10	<25	6.9	34	36
Mile 224.5 C	No.samples		5	5	5	5	5	5	5	5	5	5	5	5
	Mean		1.1	6.6	30	86	722	0.072		13	<25		39	91*
	Max.		1.9	7.7	32	100	767	0.100	0.030	10	<25	7.3	42	230
	Min.		.8	5.9	28	74	694	0.030	<0.002	15	<25	7.0	36	23

C = Centerline. All values at 3 ft. depth. (a) See Table E-4 for vertical cross-section values. *Median.

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 6 of 8)

Table E-3 - Individual Results, Sanitary Examinations, Ouachita River, Miles 351.0 to 133.0

Summary

Station	Samples	Ave.Daily Flow CFS	5-day B.O.D. 20° C.	D.O. ppm	Temper-ature, °C.	Per Cent Saturation	Cl⁻ (a) ppm	Nitrates as N, ppm	PO_4 ppm	Color, ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml.
Mile 206.7	No.samples		4	4	4	4	4	4		4	4	4	4	4
C	Mean		0.6	6.9	31	92	660	0.125		14			50	930*
	Max.		0.8	7.1	32	94	752	0.300	0.040	15	<25	7.4	53	4,300
	Min.		0.4	6.6	31	88	585	0.030	<0.002	10	<25	7.1	46	930
Bayou de Loutre	No.samples		6	6	6	6	6	5	5	5	5	5	5	2
C	Mean		2.0	6.1	30	80	548	0.074		21			52	
	Max.		2.5	8.4	30	110	582	0.100	0.010	35	27	7.5	52	430
	Min.		1.5	4.0	29	52	493	0.030	<0.002	20	<25	6.9	51	230
Mile 195	No.samples		7	7	7	7	7	7	7	7	7	7	7	7
C	Mean		1.3	6.2	31	82	687	0.094		13			48	390*
	Max.		1.5	6.8	32	89	755	0.300	0.004	15	27	7.4	52	2,100
	Min.		1.1	5.2	29	70	607	0.030	<0.002	10	<25	7.0	42	73
Bayou D'Arbonne	No.samples		6	6	6	6	6	2	2	2	2	2	2	
C	Mean		1.5	6.4	30	84	641	0.075		10			36	
	Max.		1.7	7.8	31	100	788	0.120	0.006	10	<25	7.3	46	
	Min.		1.2	5.6	28	75	440	0.030	<0.002	10	<25	6.8	27	
Mile 179.1	No.samples		10	11	11	11	9	9	9	9	9	9	9	9
	Mean	910	2.8	6.4	30	84	673	0.083		16			49	43,000 *
	Max.	1080	16	7.2	32	100	738	0.250	0.020	60	43	7.3	77	240,000
	Min.	785	1.0	2.4	28	31	594	0.030	<0.002	10	<25	7.0	43	7,300

C = Centerline. All values at 3 ft. depth. (a) See Table E-4 for vertical cross-section values. *Median.

ARKANSAS-WHITE-RED FIELD STUDIES

(Sheet 7 of 8)

Table E-3 - Individual Results, Sanitary Examinations, Ouachita River, Miles 351.0 to 133.0

Summary

Station	Samples	Ave.Daily Flow CFS	5-day B.O.D.	D.O. ppm	Temper-ature, °C.	Per Cent Saturation	Cl⁻ (a) ppm	Nitrates as N, ppm	PO_4 ppm	Color ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml.
Mile 178.8 C	No.samples		1	1	1	1								
	Value		1.6	6.2	28	78								
Mile 178.7 C	No.samples		1	2	2	2								
	Mean		3.6	1.9	28	24								
	Max.			3.8	29	48								
Black Bayou C	Min.			0	28	0								
Mile 178.6 C	No.samples		1	3	3	3								
	Mean		1.2	2.1	29	27								
	Max.			6.3	29	80								
	Min.			0	28	0								
Black Bayou C	No.samples		6	7	7	7	6	6	6	6	6	6	6	
	Mean		135	0.8	33	10	547	0.587		337	378	Est	286	
	Max.		230	5.3	38	70	861	1.000	0.006	625	1225	9.8	420	
	Min.		28	0	28	0	291	0.050	<0.002	30	101	7.6	97	
Mile 178 C	No.samples			3	3	3								
	Mean			2.1	28	27								
	Max.			3.2	29	41								
	Min.			0	28	0								
Mile 177.6 C	No.samples		2	2	2	2								
	Mean			1.7	29	22								
	Max.		9.8	3.4	29	43								
	Min.		>3.4	0	29	0								

C = Centerline. All values at 3 ft. depth. (a) See Table E-4 for vertical cross-section values. *Median.

ARKANSAS-WHITE-RED FIELD STUDIES

Table E-3 - Individual Results, Sanitary Examinations, Ouachita River, Miles 351.0 to 133.0

(Sheet 8 of 8)

Summary

Station	Samples	Ave.Daily Flow CFS	5-day B.O.D.	D.O. ppm	Temper-ature, °C.	Per Cent Saturation	Cl^- (a) ppm	Nitrates as N, ppm	PO_4 ppm	Color ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml.
Mile 177.35	No.samples		8	9	9	9	8	8	8	8	8	8	8	8
	Mean		3.5	2.9	30	37	686	0.084		26			55	33,500*
	Max.		7.7	5.1	32	66	742	0.250	0.024	40	26	7.3	62	75,000
	Min.		1.4	1.2	28	16	596	0.020	<0.002	20	<25	7.0	46	3,600
Mile 165	No.samples		5	5	5	5	5	5	5	5	5	5	5	5
	Mean		1.5	5.1	29	66	608	0.086	0.009	23			52	7,500*
	Max.		2.0	5.9	31	73	692	0.300	0.024	25	28	7.3	58	9,300
	Min.		1.2	4.4	27	58	427	0.020	0.002	20	<25	7.0	48	1,500
Mile 153.5	No.samples		5	5	5	5	5	5	5	5	5	5	5	5
	Mean		1.6	6.2	30	82	515	0.086		19			51	150*
	Max.		2.2	7.8	33	100	693	0.300	0.004	25	25	7.3	53	390
	Min.		1.1	4.9	28	65	309	0.020	<0.002	15	<25	7.1	48	36
Mile 133	No.samples		5	5	5	5	5	5	5	5	5	5	5	5
	Mean		1.6	5.9	30	78	270	0.128		18			54	150*
	Max.		2.3	6.7	32	91	397	0.300	0.012	20	<25	7.3	59	390
	Min.		0.9	4.9	29	65	195	0.020	<0.002	15	<25	7.1	47	36

C = Centerline. All values at 3 ft. depth. (a) See Table E-4 for vertical cross-section values. *Median.

ulated in Table E-8.

Discussion

Water Quality

Dissolved Oxygen - Two areas of oxygen depletion were found during the survey. The first existed below West Two Bayou (mile 343.5) which carries the wastes from the International Paper Company pulp and paper plant at Cullendale, Arkansas. The minimum dissolved oxygen concentration occurred at mile 336, where a value of 1.6 ppm was obtained.

The second area of oxygen depletion occurred below Black Bayou (mile 178.65) which carries the wastes from the Brown Paper Company at West Monroe, Louisiana. A minor fish kill occurred in this area during the survey. The kill was probably caused by depletion of oxygen in the stream due to wastes from Black Bayou. A series of verticle dissolved oxygen profiles were run to determine to what extent dissolved oxygen stratification occurred in this area. (See discussion of Special Studies - Oxygen Studies below Black Bayou).

Five-Day BOD at 20°C. - A plot of the data in Figure E-3 indicates two areas of abrupt increase in the 5-day BOD below West Two Bayou, and below Black Bayou. The results obtained in running dilutions on some of the samples taken below West Two Bayou are tabulated in Table E-7 in the appendix. The dilution always produced a much greater 5-day BOD than did the straight samples particularly in samples from Mile 308. In a stream, such a restriction of biological activity can be caused by an element or elements which inhibit biological growth. Such elements are sometimes found in wastes from paper mills and oil fields.

Temperature - During the survey the water temperature of the Ouachita

River averaged approximately 30°C., ranging from 27°C. to 33°C.

Chloride (Cl^-) - It was observed that chloride stratification was taking place behind Lock & Dam No.8. The discussion of the chloride results is presented under Special Studies - Brine Stratification.

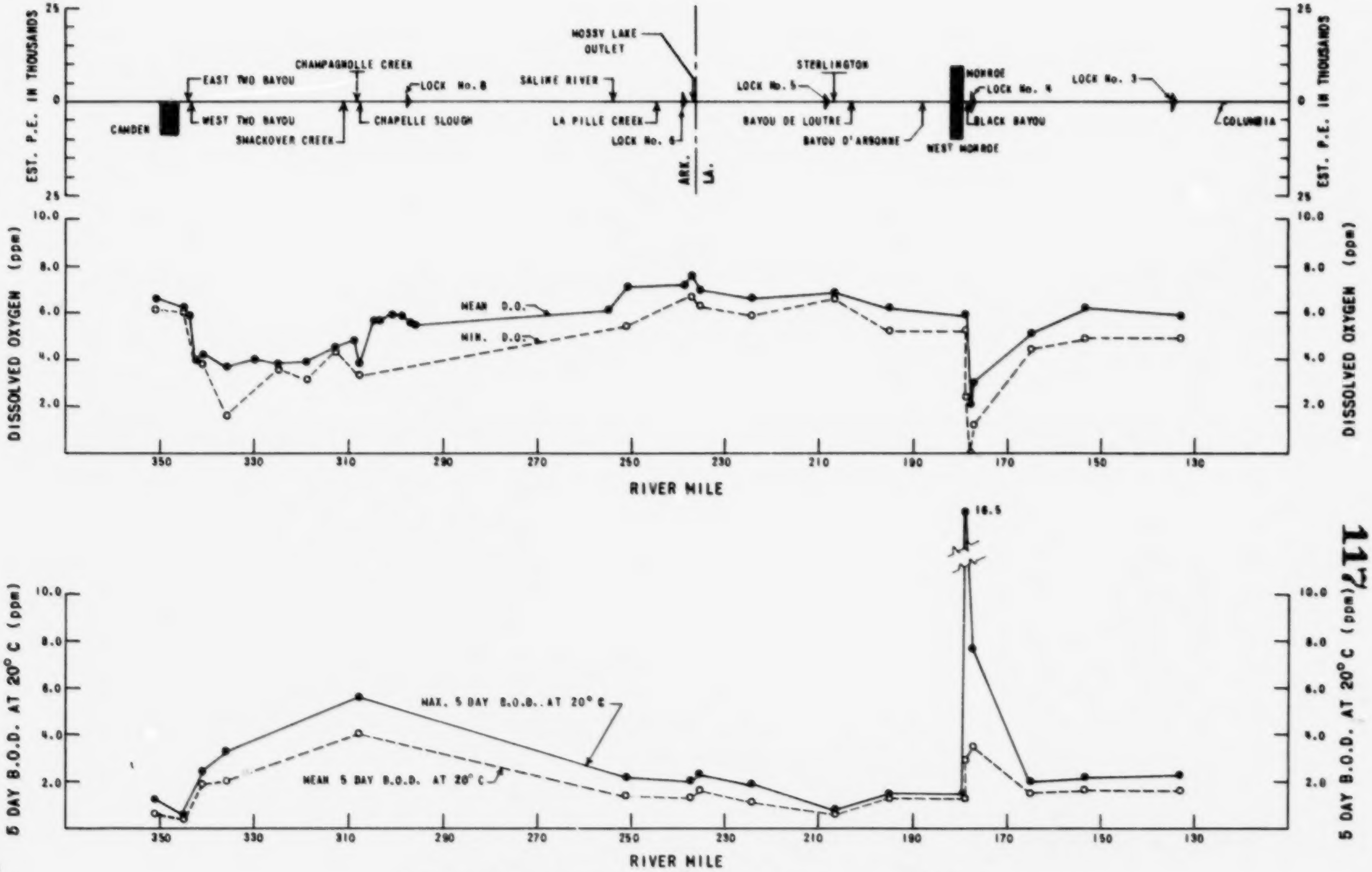
Nitrate as N - The nitrate values were fairly constant from mile 351 to mile 319, the average values ranging from 0.010 ppm to 0.025 ppm. The nitrate values in the section of river from mile 308 to mile 133 ranged from 0.062 to 0.128 ppm nitrogen, indicating an increase between miles 319 and 308, and a fairly constant condition between 308 and 133.

Phosphate (PO_4) - The highest concentrations of phosphate were found above West Two Bayou in the section of river between mile 351 and mile 344, the maximum values ranging from 0.007 ppm to 0.180 ppm. From West Two Bayou to mile 133, the phosphate concentrations remained fairly low, ranging from 0.002 ppm to 0.080 ppm. These concentrations are within the range that could stimulate the growth of most algae.

Color - The average values for color ranged between 10 ppm to 28 ppm; the highest color value occurring below West Two Bayou.

Turbidity - Turbidity was higher in the section, mile 351 to 336, than for the rest of the river, and ranged from less than 25 ppm to 112 ppm. Turbidity values for the stream stretch, mile 330 to mile 133, ranged from less than 25 ppm to 43 ppm, with the majority of samples having a turbidity of 25 ppm.

pH - The pH values ranged from 6.6 to 7.4, the higher pH occurring from the Arkansas-Louisiana state line, mile 235.5 (below Mossy Lake Outlet) to mile 133.

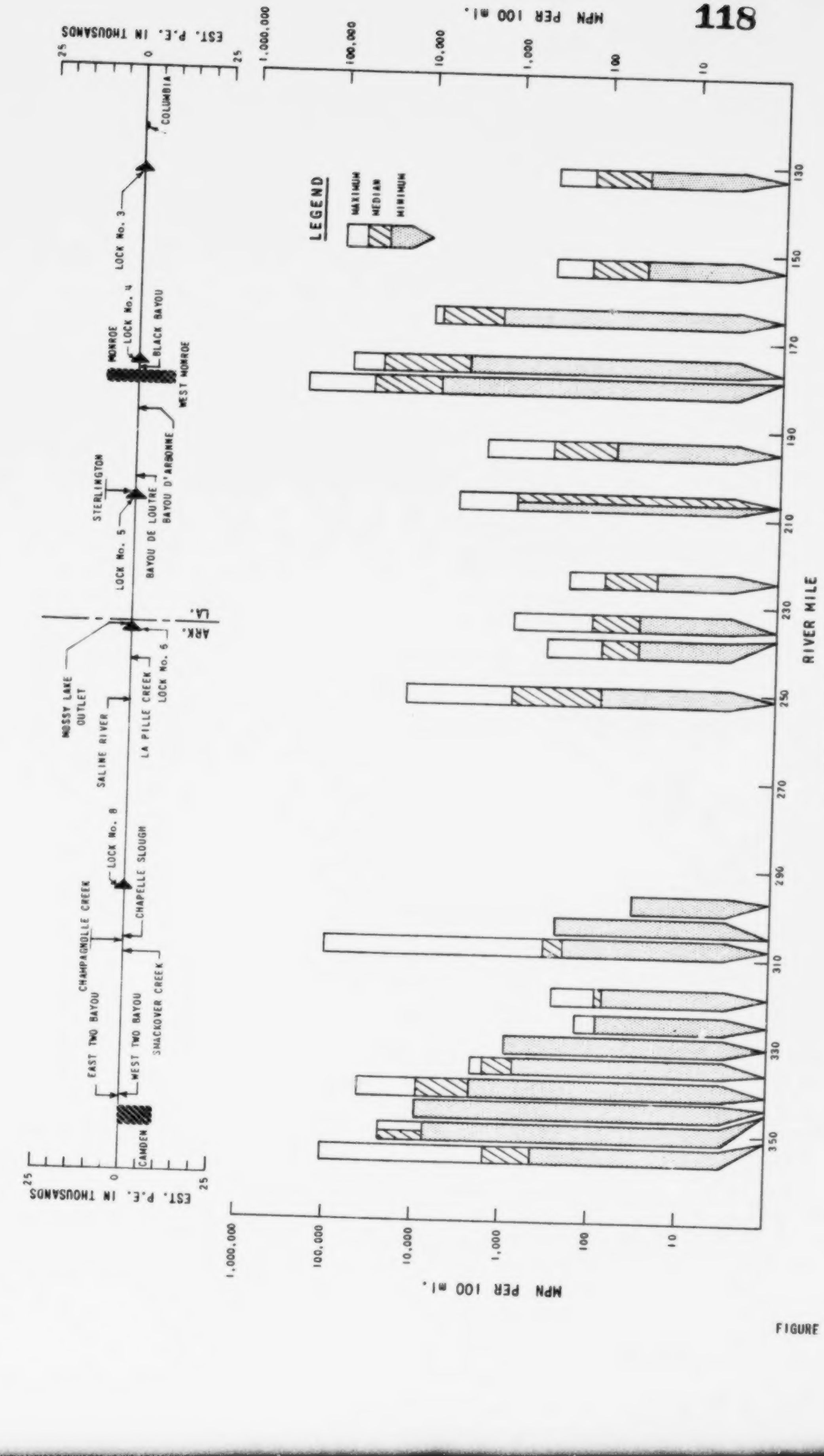


DISSOLVED OXYGEN AND 5 DAY B.O.D. AT 20°C vs. RIVER MILE

OUACHITA RIVER

(AUGUST 5, 1952 TO SEPTEMBER 10, 1952)

FIGURE E-3



COLIFORM MPN/100 ml vs. RIVER MILE
OUACHITA RIVER
(AUGUST 5, 1952 TO SEPTEMBER 10, 1952)

FIGURE E-4

Total Alkalinity - A general increase in total alkalinity occurred from mile 351 to mile 133; the average values for each station ranged from 26 ppm to 55 ppm.

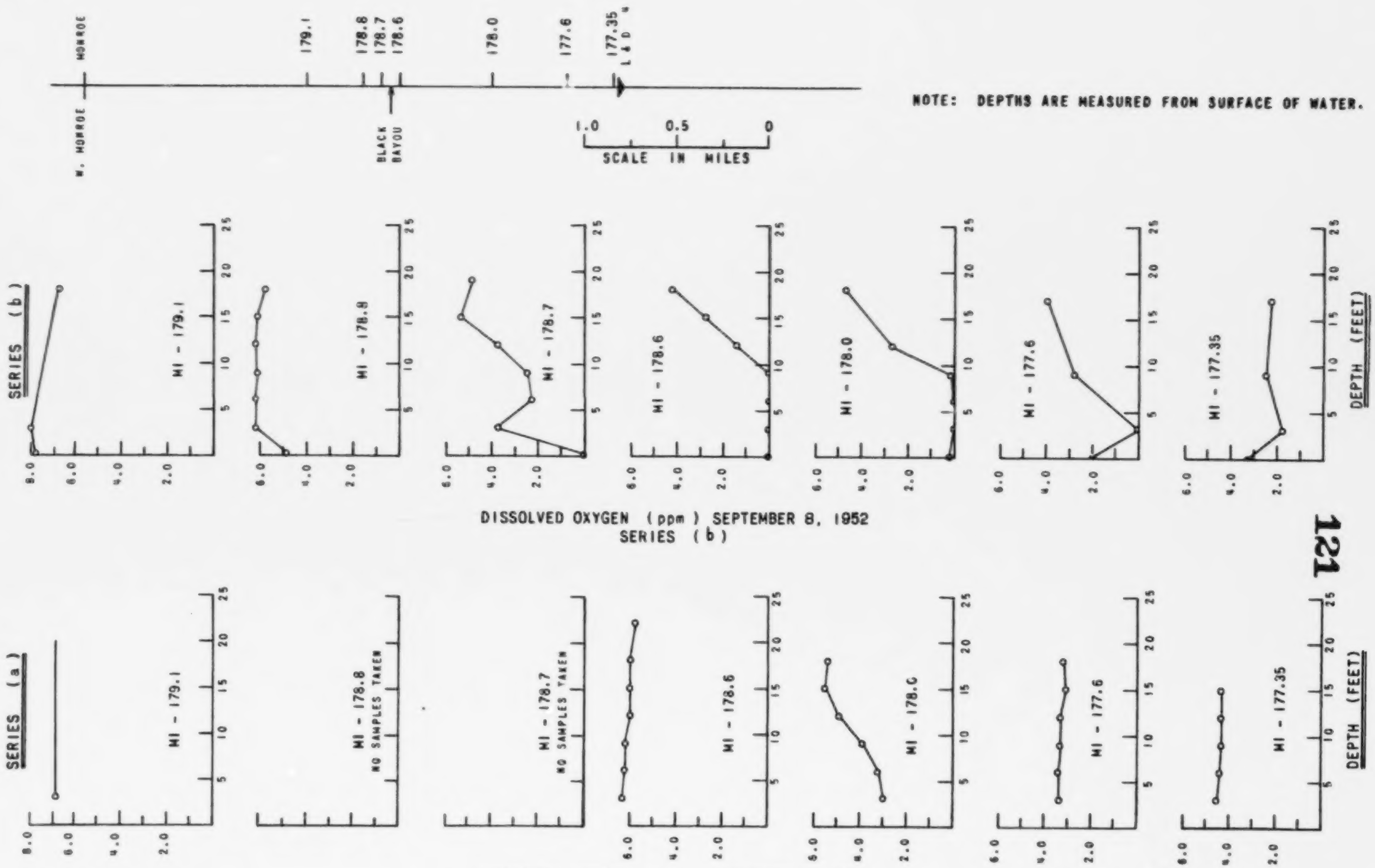
Coliform Densities - MPN per 100 ml. In figure E-4, there are four sections of the river, mile 345, 251, 206.7 and 179, in which coliform densities increase. These increases result from the discharge of wastes at Camden, Arkansas, Saline River, Sterlington, Louisiana, and East and West Monroe, Louisiana, respectively. Below Camden the median coliform MPN/100 ml. increased from 1500 to 24,000. The median below the confluence of the Saline and Arkansas Rivers was 930. Below Sterlington the median coliform MPN/100 ml. increased from 91 to 930. At Monroe, the median coliform MPN/100 ml. increased from 390 to 43,000.

Special Studies

Chloride Studies - Brine Stratification - During the survey a large increase in the chloride (Cl) content between mile 309 and 256 was observed. Initially all samples were taken at a three foot depth. This procedure was changed and verticle sections were run for chlorides. In table E-4, chloride values of samples taken at depths of 3 feet in the section, mile 309, ranged from 9 to 61 ppm Cl. Those from mile 308 to mile 297.6 ranged from 43 to 299 ppm. Samples from various depths in this section revealed that stratification of chlorides occurred behind Lock & Dam No.8. The chloride stratification extended upstream to mile 313. The chloride concentration near the surface was 18 ppm and near the bottom 2,150 ppm. This would indicate that, if Smackover Creek (mile 311) which carries the brine wastes from oil fields in the area was discharging the brines which caused this condition, the strata of high chlorides had moved 2 miles upstream. At mile 308, chloride concentration near the bottom was 7,410 ppm compared with a concentration of 43 ppm 3 feet from the surface. Figure E-6 is a diagrammatic representation of the chloride concentrations found during this survey. It does not show the movement of the brine downstream, as shown by the data in Table E-4. Top and bottom chloride concentrations are plotted against river miles in Figure E-7, for the section mile 351 to 237.5. There is no chloride stratification below Lock & Dam No.8. The difference in top and bottom chloride concentration at mile 251 is caused by the water from Saline River floating over the water in the Ouachita River. Evidence of corrosion of the locks' gates was visible at the base of Lock & Dam No.8.

Figure E-8 is a plot of chloride (Cl) vs. time (days of survey) by sampling stations - mile 251, mile 235.5, mile 179, mile 153.5 and mile 133. The passage of the high chloride concentrations downstream can readily be seen. The increase in chloride at stations 153.5 and 131 is quite pronounced, while stations at miles 251 and 235.5 show a definite peak followed by a decline in chloride concentration. This indicates that variations in chloride concentration in the stream result from the flushing of "slugs" of brine from oil fields.

Oxygen Studies-International Paper Co. at Cullendale, Ark. - The International Paper Company at Cullendale discharges the effluent from its lagoon into West Two Bayou which empties into the Ouachita River at mile 343.2. The effluent from this stream is dark brownish in color and contains considerable fibre. It was devoid of oxygen throughout the period of the survey. A large sludge bank was present for approximately 100 to 150 yards downstream. The



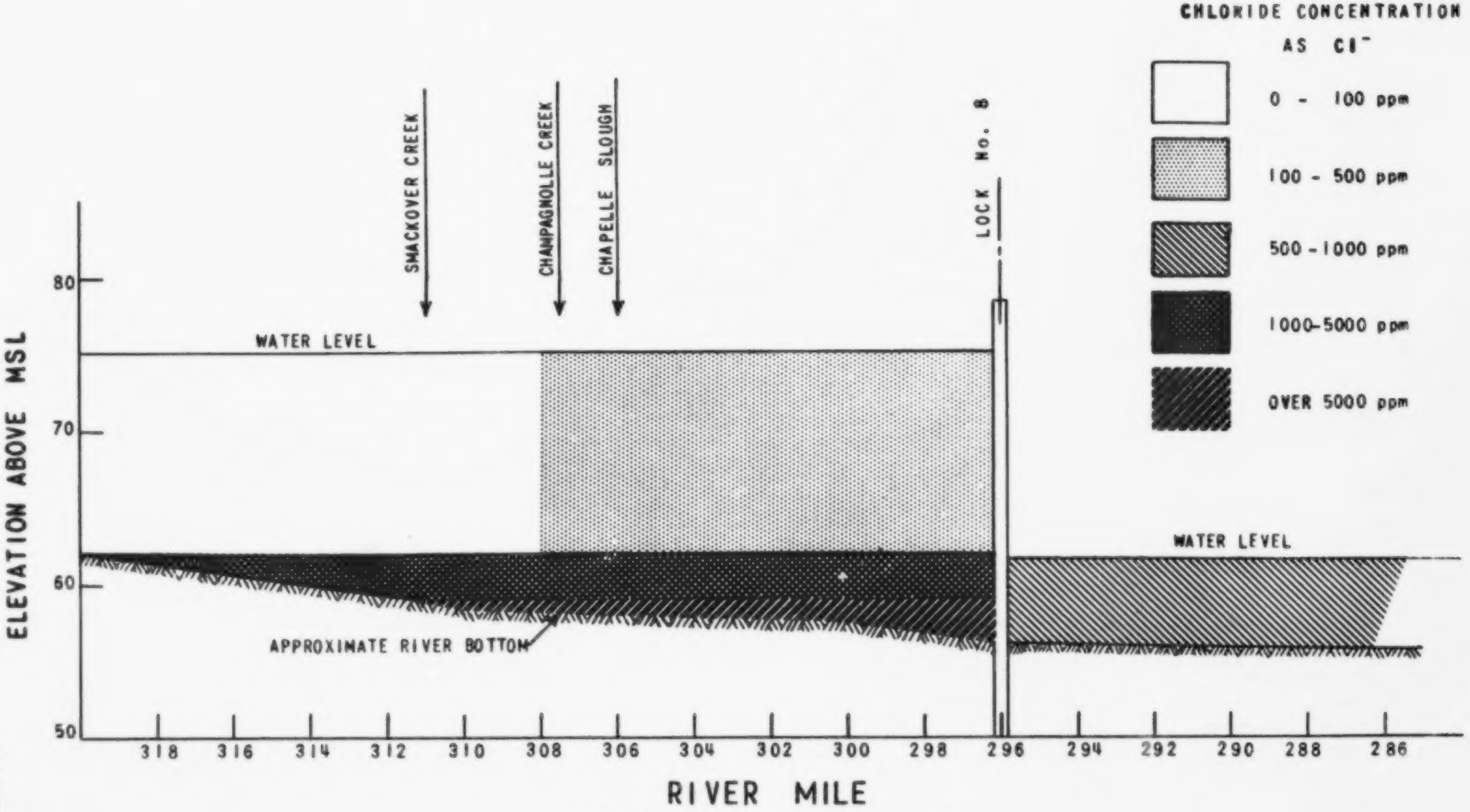
NOTE: DEPTHS ARE MEASURED FROM SURFACE OF WATER.

DISSOLVED OXYGEN (ppm) SEPTEMBER 8, 1952
SERIES (b)

DISSOLVED OXYGEN (ppm) SEPTEMBER 5, 1952
SERIES (a)

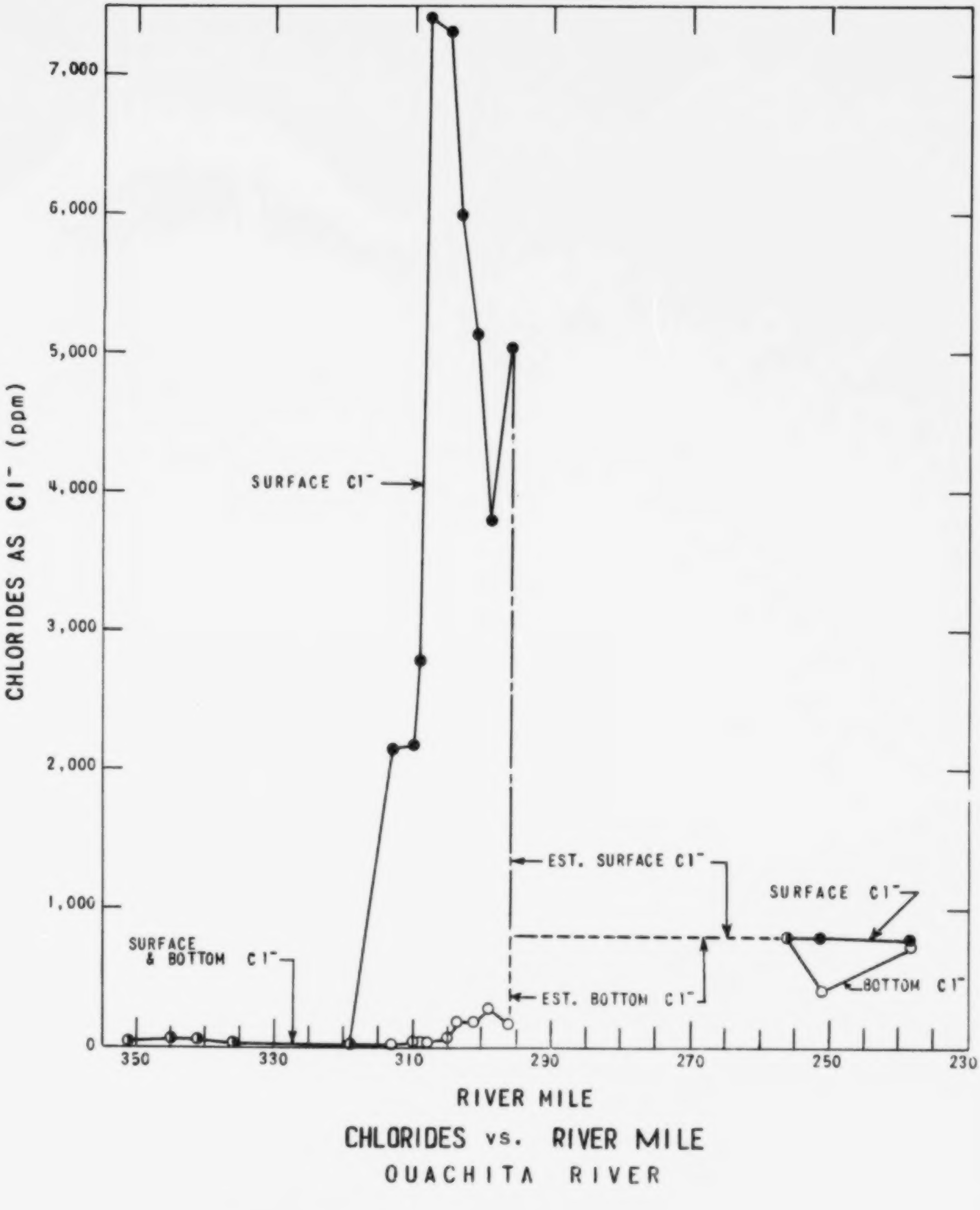
DISSOLVED OXYGEN PROFILES
OUACHITA RIVER
MILE 179.1 TC MILE 177.35

FIGURE E-5



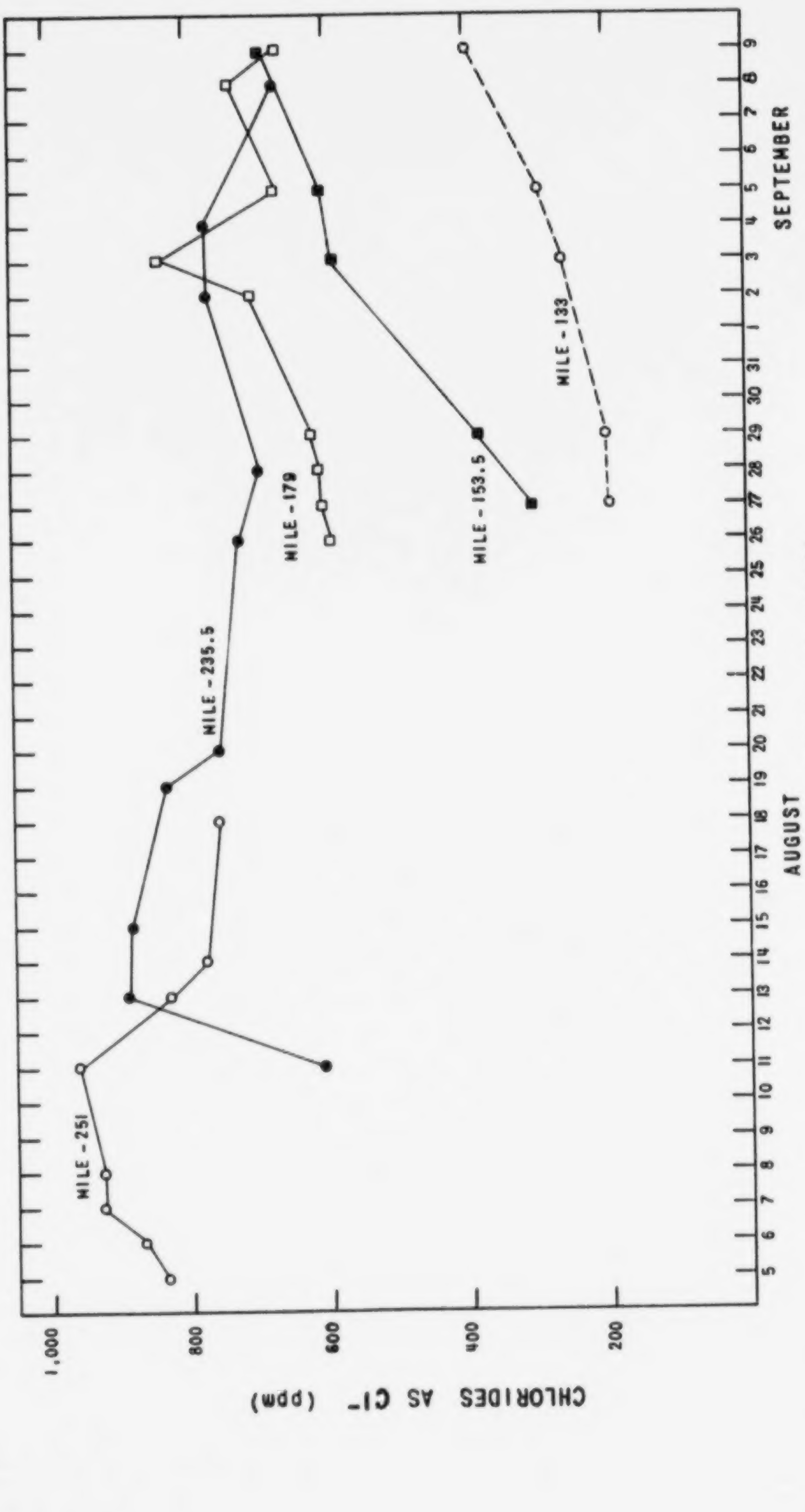
CHLORIDE STRATIFICATION
OUACHITA RIVER

FIGURE E-6



CHLORIDES vs. RIVER MILE
OUACHITA RIVER

FIGURE E-7



TIME IN DAYS

CHLORIDES vs. TIME

OUACHITA RIVER

AUGUST 5 - SEPTEMBER 9, 1952

FIGURE E-8

results of the series of dissolved oxygen profiles are shown in figure E-3. A sharp decrease in dissolved oxygen occurs immediately below West Two Bayou due to the industrial waste load carried by West Two Bayou. The mean D.O. concentrations for each station during this series ranged from 3.7 ppm to 4.8 ppm, the minimum mean concentration occurring at mile 336. The minimum dissolved oxygen values at the various sampling stations ranged from 1.6 to 4.3 ppm, the value of 1.6 ppm occurring at mile 336.

From mile 308 to mile 305 the mean dissolved oxygen increased from 3.8 to 5.7 ppm.

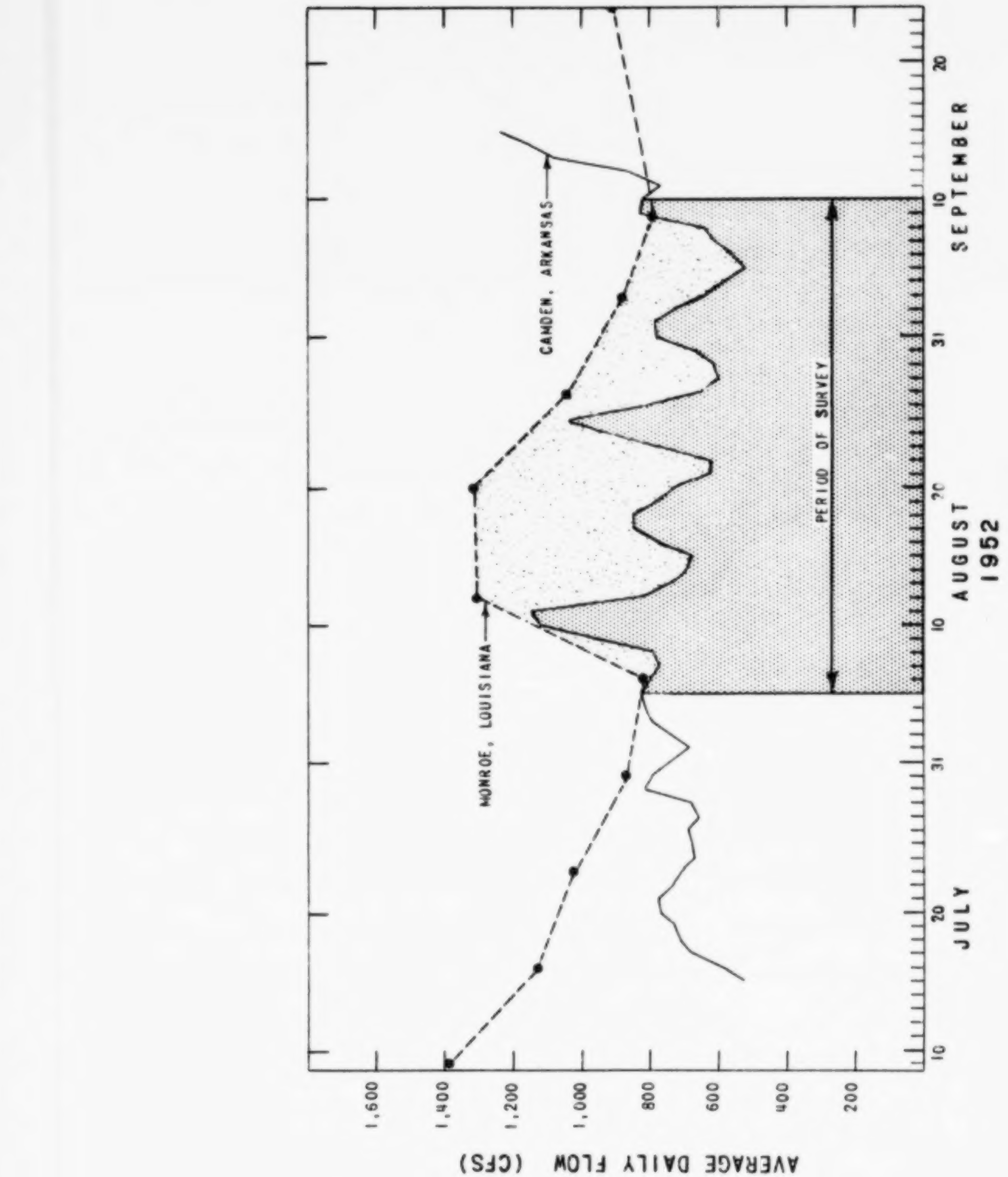
Oxygen Studies-Brown Paper Mill Co., West Monroe, La. - The Brown Paper Mill Co. discharges its wastes into Black Bayou which joins the Ouachita River at mile 178.65. The water in Black Bayou was black in color and contained considerable fibre. A large sludge bank extended approximately 150 to 200 yards downstream. A small fish kill was reported at Lock & Dam No.4, mile 177.3, during the survey. A series of vertical dissolved oxygen profiles were run between mile 179.1 and mile 177.35 to determine the oxygen conditions. Four series were conducted. Series (a) and (b) showing the two extremes, are presented graphically in figure E-8. It is estimated that from mile 178.65 to 177.3, the time of flow is one day. Series (a) shows fairly uniform concentrations of dissolved oxygen for all stations except mile 178.0 (0.65 miles below Black Bayou). At this station the dissolved oxygen varies from 3 ppm at 3 ft. depth to 5.5 ppm at a 15 foot depth. This indicates a lack of vertical mixing in this section.

Series (b) shows an entirely different condition. The difference in D.O. of 1.2 ppm between the surface and 3 ft. depth samples indicates the wastes from Black Bayou had moved upstream a distance of 0.15 miles. At station 178.7 (0.05 miles above Black Bayou) the dissolved oxygen varied from 0 ppm at the surface to 5.4 ppm at a depth of 15 feet. At mile 178.6, the river was devoid of oxygen from the surface to a depth of 9 feet. The dissolved oxygen content was 4.2 ppm at a depth of 18 feet. The dissolved oxygen concentration at station 177.6 decreased from a value of 2.0 ppm at the surface to 0 ppm at 3 feet depth and increased to 4.0 ppm at 17 feet. At station 177.35, 1.3 miles below Black Bayou, the dissolved oxygen ranged from 1.8 ppm to 3.3 ppm. The highest value occurring at the surface, and the lowest at a 3 feet depth.

The data obtained by series (b) can be interpreted as follows: 1) Laminar (non-turbulent) flow conditions exist in this section of the river; 2) Vertical mixing is slow and gradual; 3) Sampling at several depths in an impoundment may yield valuable information not determinable from a single depth sample.

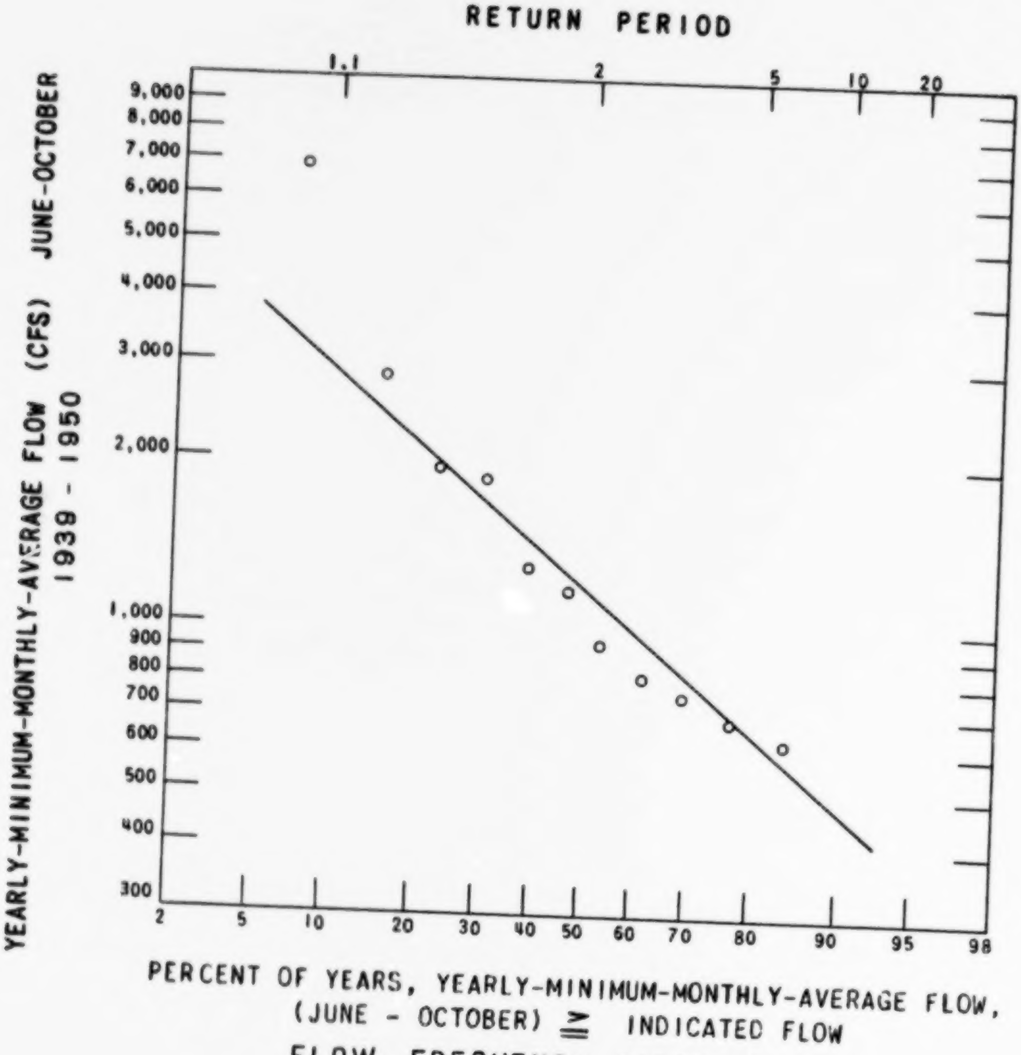
Hydrologic Data - The flow records for two stations, Camden, Arkansas, and Monroe, Louisiana, are plotted as a hydrograph in figure E-9. The gage at Camden is at the head of the impoundment formed by Lock & Dam No.8; flow data from this station are representative of the maximum velocities in the section investigated. Flows measured at Monroe, La. are probably inaccurate due to the extremely low velocities, 0.21 to 0.33 ft/sec., which are characteristic of waters impounded by locks and dams. No flows have been entered in table E-3 and E-4 for stations at which actual flow measurements have not been made.

A flow frequency plot has been prepared from records for the Ouachita River at Monroe, La., and is presented in figure E-10. The estimated flows



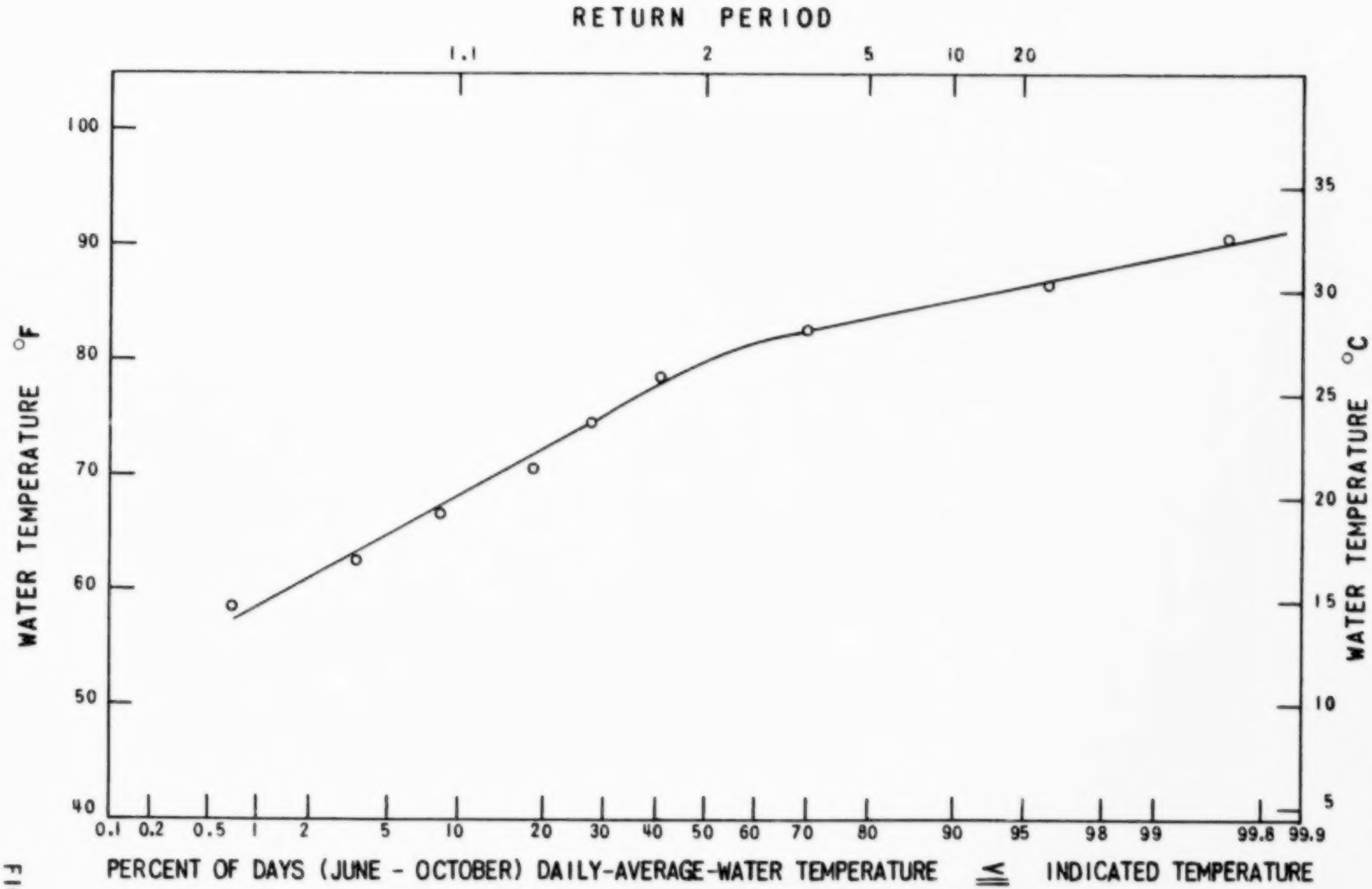
HYDROGRAPH
OUACHITA RIVER

FIGURE E-9



FLOW FREQUENCY DISTRIBUTION
OUACHITA RIVER
MONROE, LOUISIANA

FIGURE E-10



TEMPERATURE FREQUENCY DISTRIBUTION
(WATER YEARS OCTOBER, 1945 - SEPTEMBER, 1948)
OUACHITA RIVER
CAMDEN, ARKANSAS

FIGURE E-11

for and during the survey at this station, have a return period of once every two years.

Temperature Data - The average water temperature of the Ouachita River during this survey was approximately 30°C. Figure E-11 is a temperature frequency distribution plot for the Ouachita River at Camden, Ark., for the months June to October. A temperature of 30°C. which was observed during this survey, would on the basis of this analysis, have a return period of approximately once every 17 days during the months of June to October.

Biological- Biological fauna were collected from the river bottom at selected station from Camden, Arkansas, to Columbia, Louisiana. The organisms found are listed in Table E-8. Collections of organisms were made at points selected primarily because of their position in respect to sources of pollution and to some extent sample stations were determined by accessibility by boat or from roads. The river throughout this reach was deep and nearly all collections of biological life were made near the edges of the stream where most of the bottom organisms appeared to live. The level of the stream is maintained by a series of navigation dams which allow very slow movement of water during low flow periods.

From Camden to West Two Bayou is a distance of about eight miles. Pulp and paper mill wastes are discharged into West Two Bayou. The organisms collected above West Two Bayou consisted of a few midge larvae, clams and annelids. Deposits of fine silt were on the bottom in the shallow water near the stream banks. At the mouth of East Two Bayou, which carries wastes from the Camden Naval Ordnance Plant, there was no effect observed either in stimulating or depressing the growth of bottom fauna.

From the mouth of West Two Bayou and downstream for several miles the color of the water was darkened considerably, due to the discharge of pulp and paper mill wastes. No organisms were found near the mouth of West Two Bayou where there were masses of slowly decomposing fibers and a noticeable kraft odor. About a mile below the West Two Bayou numerous large gar were observed breaking water and swimming about. Turtles were also observed in large numbers.

At mile 337, about five miles below the mill effluent, two types of snails (Pleuroceratidae and Viviparidae) were found in large numbers. They were also numerous at mile 318 but thereafter decreased greatly in numbers downstream to near the State line. Annelids were fairly numerous at mile 337 and were found at each station downstream in varying numbers. The presence of oil on the surface of the water, on the shore line and on the bottom, was particularly noticeable at mile 307 near Calion. A red material, presumably iron compounds, appeared in considerable quantity on the surface of the bottom sample taken from mile 307. In spite of the presence of oil and other materials, numerous annelids, some chironomid larvae, a clam and a leach were found at this station.

Below Lock & Dam No.6, midge and mosquito larvae were collected above and below Mossy Lake outlet. Annelids which were found all along the area from below Lock & Dam No.6 to the State line were particularly numerous near the outlet of Mossy Lake. Gar were observed to be especially numerous and active just below the Mossy Lake outlet.

Sampling in the Ouachita River in Louisiana was carried on in September and again in October. Snails, midge larvae, and segmented worms (annelids)

Table E-8 - Bottom Organisms, Ouachita River
Camden, Ark., to Columbia, La.
(Collected August-October, 1952)

(Sheet 1 of 3)

Station	Insects	Mollusca	Annelida	Remarks
Mile 350 at Camden-U.S. 79 highway bridge	Diptera Chironomidae, few		Few	Silt bottom - A little green algae present
Mile 345 at Bradley Ferry	Diptera Chironomidae, few	Clams, few		Heavy silt - Spirogyra, Oscillatoria, and other algae present
Mile 343, East Two Bayou	Diptera Chironomidae, few		Few	Silt bottom and dead vegetation
Mile 342.5, West Two Bayou	No bottom fauna - fibers from pulp and paper mill decomposing.			
Mile 337, Whitehall Landing		Snails, two genera, numerous	Fairly numerous	Soft bottom - Spirogyra abundant
Mile 318, Miller's Bluff Landing		Snails numerous	Very numerous	Silt and fine sand
Mile 307, near Calion	Diptera Chironomidae, few	Clams, few	Annelida, numerous leech, one	Fine sand, oil present
Mile 237, below Lock #6, above Mossy Lake	Diptera Chironomidae, numerous Culicidae (Chaoborus) numerous Ceratopogonidae few		Numerous	Fine sand
Mile 236 at Mossy Lake outlet			Very numerous	Silt, with dead vegetation

Table E-8 (Continued)

(Sheet 2 of 3)

Station	Insects	Mollusca	Annelida	Remarks
Mile 235 State Line	Diptera Culicidae (Chaoborus) one Chironomidae few		Few	Bottom varied, sand and clay
Mile 224 Alabama Landing	Diptera Chironomidae, numerous Family(?), one Ephimeridae, few Coleoptera Dytiscidae few	Snails numerous Clams few	Few	Soft bottom - Green algae, Spirogyra, abundant
Mile 208 above Sterlington	Diptera Chironomidae, few Odonata Dragonfly, few	Snails very numerous Clams, few	Numerous	Soft bottom - Green algae abundant
Mile 207-205	Diptera Chironomidae, numerous	Snails, few	Numerous	Soft bottom, also clay - Green algae abundant
	(All organisms found at mile 205. No organisms could be found between mile 207 and mile 206)			
Mile 195	Diptera Chironomidae, numerous	Snails numerous	Numerous	Sand and silt
Mile 180 below Monroe	Diptera Chironomidae, numerous Odonata Dragonfly, few Coleoptera Dytiscidae, few	Snails numerous Clams, few	Numerous	Soft bottom - Green algae abundant: Microspora, diatoms Blue-green: Ulothrix, Phormidium Fungus
Mile 177 above #4 Lock	Diptera Chironomidae, numerous Odonata Dragonfly, numerous	Snails numerous	Very numerous	Soft bottom - Green algae, microspora

Table E-8 (Continued)

(Sheet 3 of 3)

Station	Insects	Mollusca	Annelids	Remarks
Mile 175 above Roselawn Landing	Diptera Chironomidae, very numerous Ephimerida Mayfly, few Odonata Dragonfly, few Coleoptera, one	Snails numerous Clams, few	Numerous	Silt and sandy - Green algae: Microspora, diatoms. Blue-green: Oscillatoria
Mile 153 Boscoe Landing	Odonata Dragonfly, few	Snails very numerous	Very numerous	Silt and sandy
Mile 133 above #3 Lock	Diptera Chironomidae, numerous Ephimerida Mayfly, few Odonata Dragonfly, one Coleoptera Dytiscidae one	Snails numerous Clams, few	Very numerous	Sandy and clay
Mile 125 Columbia, La.	Diptera Chironomidae, numerous Coleoptera, one Odonata Damsel fly, one	Snails numerous Clams, few	Very numerous	Soft and sandy - Fresh water shrimp numerous

were usually found in abundance at each station. Insect forms, other than the chironomids, were never found in great numbers.

The farthest upstream sampling station in Louisiana was at river mile 224 (Alabama Landing). This station was eleven miles downstream from the State line. Especially numerous at this station were snails - a very large population lived near the shore - other bottom fauna consisted of chironomids, annelids, clams, beetles and mayflies. The mayflies were found very close to the shore, usually attached to some of the grasses.

Above Sterlington at mile 208 snails were found in great numbers. A few clams, numerous annelids, some chironomids and a few dragon flies were also found. Below the Commercial Solvents Chemical Plant at Sterlington there was an absence of any animal life for about the first mile. Downstream, numerous chironomids, annelids and snails were collected. Green and blue-green algae were fairly abundant and were frequently collected along with bottom organisms, both above and below Sterlington.

At mile 195 annelids and snails were numerous. Midge larvae were also collected.

At mile 180, which was below the City of Monroe, the bottom fauna was not appreciably different from that above Monroe. Midge larvae, snails and annelids were found in about the same numbers. A few dragon flies and beetles were also found. Algae, both green and blue-green, were more abundant at this station than above Monroe.

The effluent from Black Bayou (mile 178.5) consisted primarily of pulp mill wastes and the temperature of the effluent was several degrees higher than the river temperature. The effluent spread out over the surface of the river. The color of the effluent was noticeable downstream as far as Lock #3, a distance of 45 miles. Large mats of decomposing fiber were near the outlet of Black Bayou. No organisms were found near this stream. A short distance below Black Bayou gar were observed to be very numerous.

About a mile and a half below Black Bayou at about mile 177, annelids were very numerous, being several times as densely populated as at any other station. Snails were also numerous and chironomids were found in moderate numbers. Along the edge on some of the grasses dragon fly larvae were found in moderate numbers.

At mile 175 about 2 miles below Lock & Dam No.4 midge larvae, snails and clams were particularly abundant. Annelids were fairly numerous and dragon flies, may flies and gammarus were also found. The water was quite dark at this station from the discharge of pulp mill wastes at Black Bayou, some 3-1/2 miles upstream. Judging from the fair variety of bottom fauna collected at mile 175, it does not appear that the pulp mill wastes seriously affect the bottom fauna, at least not that found near the edges of the stream. There was no visual evidence of city sewage in the river at this station.

At mile 153 snails and annelids were especially numerous and it is indicated that large supplies of organic materials are still present in the stream at this point, pulp and paper mill wastes and municipal sewage being the principal known wastes discharged to the river below Monroe at about mile 177.

At mile 133, just above Lock & Dam No.3, several annelids, snails and midge larvae were collected. Clams, gammarus, beetle larvae, mayflies and dragon flies were also found but in very small numbers. It is not known to what extent upstream sources of pollution limit the quantity of bottom fauna at this station. The presence of may flies indicates, however, that pollution is not so adverse that these relatively sensitive organisms are eliminated.

At mile 125 (Columbia, Louisiana) the dark color of the water was no longer visible on the date of sampling. Predominate bottom fauna were snails, clams and fresh water shrimp. A few insect forms such as midges, beetles and damsel flies were also found at this station. Indications were that at this station organic materials were still abundant in the stream but that a fairly good equilibrium between the available food supply and organisms had been established.

In the reach of the river from Camden, Arkansas, to Columbia, Louisiana, the river is maintained at a nearly constant level during low flow periods. Collections of bottom fauna were made near the shores in slowly moving water. Bottom deposits varied at different locations and consisted of silt, clay or fine sand. Chironomids, snails and annelids were the predominate organisms found. Several other organisms, including insects, were found at various stations. Pulp and paper mills not only affected the visible appearance of the water but below each outfall large populations of snails appeared. The increased numbers of gar below these outfalls were also noticeable. These sources of organic pollution stimulated the growth of certain organisms downstream from the outfalls. It was difficult to tell whether or not sources of pollution inhibited the growth of organisms since very few organisms were found anywhere in the river that could be classified as strictly clean water forms. For a distance of about one mile below Sterlington the absence of any organisms indicated that pollution existed that rendered this section of the river unproductive.

Local residents along the watercourse expressed the view that periodic discharges of wastes, particularly from the pulp mills, not only visibly affected the water but caused fish kills from time to time. Most of the organisms collected are fairly tolerant of pollution and could normally tolerate more pollution than the fishes. Examination of Table E-8 will show that in many instances certain organisms are more numerous below sources of pollution.

Although no particular effort was made to collect algae, much of it was collected along with bottom organisms. *Spirogyra* was especially abundant below the pulp mill near Camden where masses of it were frequently seen. Green algae grew abundantly near the shore at most stations. Blue-green algae were most abundant below Monroe at miles 180 and 175.

APPENDIX

Part B - Tables Nos. B-4, B-5, B-6, B-7, B-8, B-9

Part C - Tables Nos. C-4, C-5

Part D - Table Nos. D-3, D-4

Part E - Table Nos. E-4, E-5, E-6, E-7

(Sheet 1 of 6)

ARKANSAS-WHITE-RED FIELD STUDIES

Table B-4 - Individual Results, Sanitary Examination - Arkansas River and Tributaries, Mile 530 to Mile 428.4

Station*	Date Sampled 1952	Avg. Daily Flow, cfs, at Tulsa, Okla.	B.O.D. 5-day 20°C, ppm	D.O., ppm	Temperature, °C	Per Cent Saturation	Time	Coliforms MPN per 100 ml	Nitrates as N, ppm	PO_4^{---} ppm	Cl^- ppm	Turbidity ppm	Color, ppm	pH	Total Alkalinity, ppm
Mile 530	9/23	410	3.8	9.4	20	100	1025	4,300	0.20	<0.002	1,660	67	20	8.1	154
	9/29	362	6.3	8.9	23	100	1115	7,500	.10	.004	1,370	60	15	8.0	144
	10/1	362	4.4	9.2	24	110	1200	4,300	.18	< .002	1,350	63	15	7.9	144
	10/2	362	5.4	8.6	18	100	0850	4,300	.20	.002	1,360	56	20	8.2	142
	10/3	362	5.4	8.4	15	84	0830	4,300	.11	.002	1,360	53	20	7.7	148
Mile 523.9	9/23	410	4.0	9.4	20	100	1116	93,000	.12	< .002	1,620	60	25	8.1	152
Mile 522.8	9/23	410	4.4	10.2	22	118	1140	93,000	.25	< .002	1,640	55	25	8.4	149
Mile 519.9	9/29	362	7.3	9.5	25	120	1205	930,000	.12	.240	1,340	38	20	7.9	148
	10/1	362	9.4	4.9	25	60	1120	4,300,000	.20	.200	1,340	46	25	7.6	147
	10/2	362	9.1	4.7	19	51	0950	430,000	.20	.180	1,310	49	25	7.6	152
	10/3	362	8.1	3.4	15	34	0915	930,000	.10	.180	1,320	53	25	7.5	154
0.5'	10/6	362	18	7.2	14	79		930,000	.25	.080	1,330	54	25	7.6	159
2.0'	10/6		20	7.3	14	72	1110								
Mile 514.9	9/23	410	6.1	10.4	24	125	1215	460,000	.27	.190	1,510	39	25	8.3	156
	9/29	362	5.6	12.8	26	159	1230	150,000	.12	.200	1,350	30	20	8.3	144
	10/1	362	7.1	7.2	25	88	1055	1,500,000	.22	.500	1,320	38	25	7.6	167
	10/2	362	7.0	7.1	20	79	1020	2,400,000	.18	.400	1,300	44	25	7.9	156
	10/3	362	6.1	6.1	18	66	0945	1,500,000	.09	.420	1,340	47	25	7.6	156
0.5'	10/6	362	13	7.4	14	73		430,000	.27	.130	1,360	54	30	7.5	162
2.0'	10/6		15	7.6	14	75	1025								

* All samples taken at mid-depth unless otherwise indicated.

(Sheet 2 of 6)

ARKANSAS-WHITE-RED FIELD STUDIES

Table B-4 (Continued) - Individual Results, Sanitary Examination, Arkansas River and Tributaries, Mile 530 to Mile 428.4

Station*	Date Sampled 1952	Avg. Daily Flow, cfs, at Tulsa, Okla.	B.O.D. 5-day 20°C, ppm	D.O., ppm	Temperature, °C	Per Cent Saturation	Time	Coliforms MPN per 100 ml	Nitrates as N, ppm	PO_4^{---} ppm	Cl⁻ ppm	Turbidity ppm	Color, ppm	pH	Total Alkalinity, ppm
Mile 507.6	9/23	410	5.8	11.6	23	136	1245	1,100,000	0.30	0.240	1,390	47	30	8.1	158
	9/29	362	5.8	14.0	26	173	1255	240,000	.14	.280	1,290	35	25	8.4	148
	10/1	362	3.7	6.7	23	79	1027	150,000	.19	.560	1,300	31	25	7.8	152
	10/2	362	5.7	8.5	20	95	1105	2,400,000	.22	.430	1,280	30	25	8.0	158
	10/3	362	6.2	6.8	18	73	1025	930,000	.12	.390	1,290	38	25	7.8	158
	10/6	362	6.0	7.8	13	75	0940	930,000	.28	.370	1,320	36	25	7.7	169
Mile 483.8	9/22	422	5.4	10.2	18	109	0908	24,000	.11	.006	1,220	33	25	8.4	148
	9/23	410	5.5	9.7	18	100	0900	24,000	.15	.002	1,210	51	25	8.5	146
	9/25	386	5.5	11.7	20	130	1000	93,000	.15	.008	1,370	64	25	8.3	122
	9/30	362	8.5	12.8	25	155	1130	460,000	.15	.004	1,250	60	25	7.9	112
	10/1	362	5.6	9.8	22	110	0940	1,100,000	.20	.002	1,240	63	25	7.9	112
	10/2	362	9.5	14.2	20	157	1155	460,000	.20	.006	1,250	60	25	8.5	120
	10/3	362	6.4	11.3	19	123	1130	93,000	.11	.040	1,280	52	25	8.4	146
Mile 466.2	9/22	422	6.3	10.2	19	111	1013	24,000	.15	.002	1,180	53	25	8.4	124
	9/23	410	5.9	10.4	21	118	1010	9,300	.10	.004	1,210	65	25	8.6	123
	9/24	398	>7.6	14.0	24	166	1500	7,500	.28	.002	1,230	70	30	8.7	104
	9/25	386	6.4	12.4	24	148	1405	1,400	.20	< .002	1,260	76	30	8.7	104
	9/26	374	6.5	10.1	22	116	1010	24,000	.05	< .002	1,280	80	25	7.6	108
	10/1	362	5.9	10.7	26	133	1225	9,300	.18	.002	1,210	86	25	7.9	104
	10/2	362	7.9	9.0	19	98	0950	9,300	.23	.002	1,230	65	25	8.1	111
0.25'	10/6	362	7.1	12.0	15	120									
1.5'	10/6		7.2	11.9	14	117	1345	2,100	.24	.006	1,230	59	25	8.2	134
0.5'	10/8	362	7.2	12.3	14	121									
1.5'	10/8		7.2	12.3	14	121	1216				1,180	44	20	8.3	154
	10/9	362	8.8	11.9	15	119	1145				1,180	49	20	8.4	152
	10/10	362					1040				1,220		15	7.9	149

* All samples taken at mid-depth unless otherwise indicated.

ARKANSAS-WHITE-RED FIELD STUDIES

Table B-4 (Continued) - Individual Results, Sanitary Examination, Arkansas River and Tributaries, Mile 530 to Mile 428.4

Station*	Date Sampled 1952	Avg. Daily Flow, cfs, at Tulsa, Okla.	B.O.D. 5-day 20°C, ppm	D.O., ppm	Temperature, °C	Per Cent Saturation	Time	Coliforms MPN per 100 ml	Nitrates as N, ppm	PO_4^{---} ppm	Cl^- ppm	Turbidity ppm	Color, ppm	pH	Total Alkalinity, ppm
Mile 461.7	9/22	422	6.8	10.3	20	114	1115	750,000	0.15	0.004	1,150	56	30	8.3	127
	9/23	410	9.4	10.2	21	103	1100	91,000	.12	.006	1,180	67	30	8.5	121
	9/24	398	6.3	12.9	25	157	1535	23,000	.27	< .002	1,170	90	30	8.7	106
	9/25	386	5.5	11.2	24	134	1435	93,000	.21	.002	1,220	86	30	8.5	104
	9/26	374	6.4	9.8	22	110	1040	430,000	.06	.002	1,260	84	25	7.7	109
	9/29	362	8.2	8.9	23	96	1020	23,000	.10	.004	1,300	81	20	8.1	106
	9/30	362	8.3	7.8	21	88	0830	43,000	.12	.006	1,220	82	20	7.9	106
0.25'	10/6	362	12	10.7	15	107									
1.5'	10/6		12	10.7	15	107	1310	4,600,000	.30	.004	1,230	73	25	7.7	133
0.5'	10/8	362	9.7	11.2	15	113									
1.5'	10/8		9.2	11.3	15	113	1251				1,210	47	20	8.0	154
	10/9	362	8.5	11.2	14	109	1120				1,180	64	20	8.4	141
	10/10	362					0950				1,210		15	7.9	150
Old 69 Br. over Verdigris R.	9/22	60**	1.8	7.3	24	86	1138	640	.13	.002	306	26	10	7.9	169
	9/23	51**	2.3	8.6	25	100	1305	430	.13	.008	306	31	10	8.4	166
	9/24	49**	2.5	9.4	24	110	1555	350	.17	.004	308	36	10	8.4	159
	9/25	49**	2.1	8.4	24	99	1455	150	.08	.010	314	37	10	8.3	161
	9/29	48**	2.1	8.7	24	100	1055	1,200	.12	.008	329	27	10	8.3	161
	9/30	47**	1.4	8.0	22	91	0900	200	.15	< .002	325	37	10	8.2	155
	10/3	46**	1.4	5.9	20	65	0855	390	.09	.008	322	31	10	7.7	156
	10/9	64**	1.0	7.7	15	76	1110				345	29	10	7.9	157
	10/10	56**					0910				348		10	7.6	143

* All samples taken at mid-depth unless otherwise indicated.

** Flow as measured at Inola, Okla.

(Sheet 4 of 6)

ARKANSAS-WHITE-RED FIELD STUDIES

Table B-4 (Continued) - Individual Results, Sanitary Examination Arkansas River and Tributaries, Mile 530 to Mile 428.4

Station**	Date Sampled 1952	Avg. Daily Flow, cfs, at Tulsa, Okla.	B.O.D. 5-day 20°C, ppm	D.O., ppm	Temperature, °C	Per Cent Saturation	Time	Coliforms MPN per 100 ml	Nitrates as N, ppm	PO_4^{---} ppm	Cl- ppm	Turbidity ppm	Color, ppm	pH	Total Alkalinity, ppm
Grand R. at Fort Gibson	9/22	1,630*	1.0	8.2	23	95	1208	230	0.28	0.002	15	41	5	7.8	123
	9/23	1,810*	1.0	8.5	21	95	1355	91	.30	.010	15	38	5	8.0	121
	9/24	1,950*	1.4	9.0	23	100	1620	1,500	.34	.010	14	48	5	7.9	120
	9/25	2,530*	.8	8.8	22	99	1520	230	.27	.012	15	42	5	7.9	120
	9/29	1,830*	.6	8.1	22	92	1135	230	.35	.020	14	30	10	7.7	123
	9/30	1,830*	.8	8.2	22	93	0935	2,400	.35	.006	13	25	10	7.7	117
	10/2	1,100*	.9	8.2	21	91	1055	230	.30	.002	16	<25	5	7.7	121
	10/9	875*	1.0	8.8	15	87	1045				15	28	5	7.7	122
	10/10	714*					0850				13		5	7.7	115
		At Muskogee													
Mile 457.8	9/22	2,770	3.1	9.1	22	109	1230	2,300	.20	< .002	269	36	15	8.0	124
	9/23	2,140	4.4	10.1	23	117	1420	24,000	.20	.006	400	42	15	8.1	122
	9/24	2,480	2.2	9.7	23	110	1640	43,000	.32	.004	192	55	10	8.1	116
	9/25	3,190	1.7	9.0	23	104	1545	24,000	.25	.008	109	45	10	7.9	118
	9/26	2,980	2.0	8.4	21	94	1105	2,300	.20	.006	166	36	10	7.8	123
	9/29	2,480	2.0	8.6	22	98	1155	4,300	.20	.006	214	30	10	7.9	122
	9/30	2,480	2.2	8.2	22	93	1005	4,300	.20	< .002	200	31	10	7.8	117
	10/3	1,660	3.2	8.1	17	84	0930	7,500	.13	.006	428	37	10	7.6	120
0.25'	10/6	1,610	2.4	10.0	16	101									
2.5'	10/6		2.7	9.9	15	99	1245	910	.25	.002	364	35	15	7.7	125
0.25'	10/7	1,480	2.8	9.3	15	93									
1.5'	10/7		2.3	9.3	15	93	0915				403	37	10	7.7	126
0.5'	10/8	1,420	3.1	10.2	14	99									
1.5'	10/8		3.2	10.2	14	99	1100				405	32	15	7.9	132
	10/9	1,430	3.4	9.3	14	90	0845				405	41	10	7.9	134
	10/10	1,320					0820				432		15	7.9	132

* Flow as measured at Fort Gibson, Okla.

** All samples taken at mid-depth unless otherwise indicated.

(Sheet 5 of 6)

ARKANSAS-WHITE-RED FIELD STUDIES

Table B-4 (Continued) - Individual Results, Sanitary Examination, Arkansas River and Tributaries, Mile 530 to Mile 428.4

Station*	Date Sampled 1952	Avg. Daily Flow, cfs, at Muskogee, Ok.	B.O.D. 5-day 20°C, ppm	D.O., ppm	Temperature, °C	Per Cent Saturation	Time	Coliforms MPN per 100 ml	Nitrates as N, ppm	PO_4^{---} ppm	Cl^- ppm	Turbidity ppm	Color, ppm	pH	Total Alkalinity, ppm
Mile 455.7															
0.5'	9/24	2,480						24,000							
3'	9/24			8.2	21	91	0930	4,300							
4'	9/26	2,980		8.0	23	93	0930	9,300							
0.25'	10/7	1,480	4.1	9.4	14	91									
2.5'	10/7		3.1	9.4	13	90	0925								
Mile 453.7															
0.5'	9/24	2,480						23,000							
5'	9/24			9.0	21	100	1043	43,000							
0.5'	9/26	2,980						43,000							
3'	9/26			8.0	22	91	1003								
0.25'	10/7	1,480	3.0	10.0	14	97									
3'	10/7		2.8	10.2	14	99	1040								
Mile 450.5															
0.5'	9/24	2,480						9,300							
2'	9/24			9.8	22	110	1142	9,300							
0.5'	9/26	2,980						9,300							
3'	9/26			8.4	22	94	1037	43,000							
0.25'	10/7	1,480	3.4	10.3	14	100									
3.5'	10/7		4.5	10.4	14	100	1135								
Mile 447.5	9/24	2,480	4.2	10.0	22	114	1307	240,000	0.27	0.004	381	52	20	8.4	124
Smith's	9/26	2,980	3.4	8.7	22	99	1132	93,000	.06	.002	243	31	15	7.9	124
Ferry	10/7	1,480	4.8	11.0	16	111	1300				364			8.4	133

* All samples taken at mid-depth unless otherwise indicated.

(Sheet 6 of 6)

ARKANSAS-WHITE-RED FIELD STUDIES

Table B-4 (Continued) - Individual Results, Sanitary Examination, Arkansas River and Tributaries, Mile 530 to Mile 428.4

Station*	Date Sampled 1952	Avg. Daily Flow, cfs, at Muskogee, Ok.	B.O.D. 5-day 20°C, ppm	D.O., ppm	Temperature, °C	Per Cent Saturation	Time	Coliforms MPN per 100 ml	Nitrates as N, ppm	PO_4^{---} ppm	Cl- ppm	Turbidity ppm	Color, ppm	pH	Total Alkalinity, ppm
Mile 428.4	9/24	2,480	2.7	10.7	21	119	1045	3,900	0.22	0.002	313	43	15	8.4	122
	9/25	3,190	3.1	10.6	22	121	1145	2,400	.15	.006	388	61	15	8.7	122
	9/30	2,480	2.4	9.5	23	110	0850	2,400	.13	< .002	199	54	15	8.1	116
	10/1	2,370	2.5	10.2	24	121	1045	230	.23	< .002	289	50	15	8.4	120
	10/6	1,610	2.4	9.2	15	91	1000	4,300	.24	.008	379	47	15	8.4	130
0.25'	10/7	1,480	2.6	10.5	14	102					365	48	10	8.1	129
1.5'	10/7		2.9	10.6	15	106	1130								
0.5'	10/8	1,420	6.4	11.0	13	104									
2'	10/8		6.5	10.9	13	103	0946				365	35	15	8.1	132
	10/9	1,430	4.1	11.1	12	103	0935				361	38	10	8.4	134

* All samples taken at mid-depth unless otherwise indicated.

Table B-5 - Individual Results - Effect of Algae upon Dissolved Oxygen Concentrations

Location: New U.S. 69 Bridge at Muskogee

Date	Time	Temp. °C	D.O. ppm	Per Cent Saturation
9/27/52	0130	22	8.0	92
	0200	22	7.7	88
	0300	21	7.5	84
	0400	20	7.3	81
	0500	20	7.5	83
	0600	19	7.0	76
	0700	19	7.0	76
	0800	20	7.9	87
	0900	21	8.9	100
	1000	22	9.7	111
	1100	23	10.5	122
	1200	24	11.3	134
	1300	25	12.1	146
	1400	26	12.8	158
	1500	27	13.2	165
	1600	27	13.5	169
	1700	27	13.4	168
	1800	26	12.4	153
	1900	25	11.1	134
	2000	25	10.4	126
	2100	24	9.7	115
	2200	24	8.8	104
	2300	22	8.3	95
	2400	22	8.0	92
10/10/52	1310	18	12.9	137
	1400	19	13.6	147
	1500	19	14.3	155
	1600	20	14.7	162
	1655	19	15.1	163
	1750	18	14.4	153

Table B-5 (Continued)

Location: Highway Bridge at Webbers Falls, Okla.

Date	Time	Temp. °C	D.O. ppm	Per Cent Saturation
10/10/52	1315	17	12.3	127
	1400	17	12.2	126
	1500	18	12.7	134
	1600	18	12.8	135
	1700	17	12.5	129
	1800	16	12.2	123
	1900	16	12.0	121
10/11/52	0200	14	10.8	105
	0300	14	10.9	105
	0400	13	10.9	104
	0500	13	10.8	103
	0600	12	10.7	100
	0700	12	10.5	98
	0800	13	10.7	102

Table B-6 - Arkansas River at Tulsa, Okla.

Location - Water-stage recorder, lat. 36° 08' 40", long. 96° 00' 10", in NW 1/4 sec. 11, T. 19 N., R. 12 E., at bridge on U. S.Highway 66 in Tulsa, 17 miles downstream from Cimarron River. Datum of gage is 618.23 feet above mean sea level, datum of 1929 (Corps of Engineers bench mark).

Drainage area - 74,350 square miles.

Average discharge 12 years, 7,716 second-feet; 1938-50 maximum discharge 173,000 second-feet May 20, 1943; maximum gage height 17.00 feet April 26, 1944; minimum daily discharge 147 second-feet Jan. 20, 1940.

Date 1952	Average Daily Flow, cfs	Date 1952		Average Daily Flow, cfs
Sept. 1	1120	Sept.22	Period of survey	422
2	1200	23		410
3	1040	24		398
4	860	25		386
5	806	26		374
6	754	27		374
7	722	28		362
8	706	29		362
9	690	30		362
10	658	Oct. 1		362
		2		362
11	610	3		362
12	582	4		362
13	554	5		362
14	526			
15	512	6		362
		7		362
16	498	8		362
17	484	9		362
18	484	10		362
19	470			
20	458	11		362
		12		362
21	446	13		362
		14		350
		15		350

Flow data obtained from Corps of Engineers

Table B-7 - Verdigris River near Inola, Okla.

Location - Water-stage recorder, lat. 36°10', long. 95°37', near northwest corner of sec. 4, T. 19 N., R. 16 E., at bridge on State Highway 33, 6 miles downstream from Dog Creek and 6 miles west of Inola. Datum of gage is 506.87 feet above mean sea level, datum of 1929 (levels by Corps of Engineers)

Drainage Area - 7,911 square miles.

1944-50: Maximum discharge 94,500 second-feet Apr. 22, 1945;
Maximum gage height 52.40 feet June 27, 1948;
Minimum discharge 10 second-feet Aug. 24, 1946;
Maximum stage known 54.93 feet May 21, 1943.
(Discharge 224,000 second-feet).

Date 1952	Average Daily Flow, cfs	Date 1952		Average Daily Flow, cfs
Sept. 1	65	Sept. 22	Period of survey	60
2	57	23		51
3	53	24		49
4	51	25		49
5	49	26		48
6	48	27		47
7	47	28		47
8	46	29		48
9	46	30		47
10	44	Oct. 1		47
11	44	2		46
12	43	3		46
13	41	4		44
14	38	5		44
15	36	6		44
16	35	7		65
17	38	8		78
18	141	9		64
19	100	10		56
20	72	11		51
21	69	12		48
		13		47
		14		44
		15		40

Flow data obtained from Corps of Engineers

Table B-8 - Grand (Neosho) River at Ft. Gibson, Okla.

Location - Water-stage recorder, at Ft. Gibson

Drainage Area - 12,250 square miles

Date 1952	Average Daily Flow, cfs	Date 1952		Average Daily Flow, cfs
Sept. 1	1210	Sept. 22	Period of survey	1630
2	1210	23		1210
3	1210	24		1950
4	1300	25		2530
5	1220	26		2070
6	1800	27		1830
7	1850	28		1830
8	1620	29		1830
9	2230	30		1820
10	3110	Oct. 1		1510
11	2900	2		1100
12	2250	3		1040
13	1830	4		1030
14	1830	5		1030
15	1820	6		1002
16	1820	7		940
17	2800	8		875
18	3570	9		875
19	2480	10		714
20	1830	11		606
21	1830	12		559
		13		537
		14		526
		15		526

Flow data obtained from Corps of Engineers

Table B-9 - Arkansas River near Muskogee, Okla.

Location - Water-stage recorder, lat. 35°46', long. 95°18', in NW 1/4 sec. 21, T. 15 N., R. 19 E., 1.7 miles downstream from Neosho River and 3-1/2 miles northeast of Muskogee. Datum of gage is 471.38 feet above mean sea level, datum of 1929 (Corps of Engineers bench mark).

Drainage Area - 96,409 square miles.

Average discharge 15 years, 21,950 second-feet; 1935-1950 maximum discharge 700,000 second-feet May 21, 1943 (gage height 48.20 feet); minimum discharge 340 second-feet August 12-15, 1936 (gage height 3.80 feet).

Date 1952	Average Daily Flow, cfs	Date 1952		Average Daily Flow, cfs
Sept. 1	2390	Sept. 22	Period of survey	2770
2	2390	23		2140
3	2390	24		2480
4	2580	25		3190
5	2390	26		2980
6	2690	27		2480
7	2870	28		2480
8	2770	29		2480
9	2770	30		2480
10	3900	Oct. 1		2370
11	3900	2		1730
12	3300	3		1660
13	2770	4		1640
14	2770	5		1610
15	2770	6		1610
16	2670	7		1480
17	3190	8		1420
18	4420	9		1430
19	3570	10		1320
20	2770	11		1210
21	2870	12		1180
		13		1180
		14		1150
		15		1120

Flow data obtained from Corps of Engineers

ARKANSAS-WHITE-RED FIELD STUDIES

(Sheet 1 of 4)

Table C-4 - Individual Results, Sanitary Examination, Arkansas River, Mile 168.5 to 97.1

Station	Date Sampled	Avg. Daily Flow CFS at Little Rock Arkansas	5-day B.O.D. 20° C. ppm	D.O. ppm	Temper-ature, °C.	Per Cent Saturation	Nitrates as N, ppm	PO_4 ppm	Cl^- ppm	Turbidity ppm	Color, ppm	pH	Alkalinity ppm	Coliforms MPN per 100 ml.
Mile 168.5	7-14	5060	1.2	7.1	30	94	0.300	0.08	320	<25	10	8.3	175	-
	7-16	6750	1.8	6.9	28	87	0.030	0.12	360	30	5	8.3	165	930
	7-21	5900	1.7	7.3	29	95	0.030	0.08	390	25	5	7.9	149	2400
Mile 165.8	7-17	6500	2.9	8.1	28	100	0.030	0.08	541	29	5	8.4	153	110000
	7-22	6500	2.2	7.6	30	100	0.040	0.06	297	<25	5	8.0	138	910
	7-23	7850	2.2	7.2	30	96	0.040	0.07	274	25	5	8.5	137	110000
1/4 Pt. (North)	*7-24	8150	-	6.7	30	88								
C	*7-24	8150	-	6.7	30	89								
1/4 Pt. (South)	*7-24	8150	-	6.6	30	87								
Mile 164	7-14	5060	-	6.8	30	90								
	7-16	6750	-	6.6	28	83								
	7-21	5900	-	6.8	30	90								
Mile 158	7-14	5060	2.3	7.3	30	96	0.200	0.12	330	<25	10	8.3	176	-
	7-16	6750	2.8	6.7	28	85	0.020	0.14	329	40	10	8.3	169	43000
	7-21	5900	-	7.7	30	100	0.030	0.12	462	<25	5	7.9	140	15000
Mile 155	7-14	5060	-	7.9	31	110								
	7-16	6750	-	6.8	29	88								
	7-21	5900	-	7.9	30	100								
Mile 152	7-14	5060	-	7.5	30	99								
	7-16	6750	-	6.9	29	90								
	7-21	5900	-	7.4	29	98								

* Taken at 3:00 A.M.　　C = Center Line

ARKANSAS-WHITE-RED FIELD STUDIES

Table C-4 - Individual Results, Sanitary Examination, Arkansas River, Mile 168.5 to 97.1 (Sheet 2 of 4)

Station	Date Sampled	Avg. Daily Flow CFS at Little Rock Arkansas	5-day B.O.D. 20° C, ppm	D.O. ppm	Temperature, °C.	Per Cent Saturation	Nitrates as N, ppm	PO_4 ppm	Cl^- ppm	Turbidity ppm	Color, ppm	pH	Alkalinity ppm	Coliforms MPN per 100 ml.
Mile 149	7-14	5060	-	7.8	30	100								
	7-16	6750	-	7.1	29	92								
	7-21	5900	-	8.1	29	110								
Mile 146	7-14	5060	-	7.8	31	100								
	7-16	6750	-	7.1	29	92								
	7-21	5900	-	8.0	29	100								
Mile 141	7-14	5060	2.1	8.0	30	110	0.100	0.08	304	<25	5	8.2	180	-
	7-16	6750	2.8	7.3	29	95	0.020	0.12	325	35	10	8.3	176	24,000
	7-21	5900	1.8	7.6	29	99	0.120	0.09	513	32	5	7.9	155	43,000
Mile 138	7-14	5060	-	8.0	30	110								
	7-16	6750	-	7.2	29	94								
	7-21	5900	-	8.4	30	110								
Mile 135	7-14	5060	-	7.9	30	100								
	7-16	6750	-	7.1	29	92								
	7-21	5900	-	7.9	30	100								
Mile 132	7-14	5060	-	7.9	31	110								
	7-16	6750	-	6.7	29	87								
	7-21	5900	-	8.4	28	110								
Mile 129	7-14	5060	-	8.1	30	110								
	7-16	6750	-	6.9	28	87								
	7-21	5900	-	8.0	30	110								

ARKANSAS-WHITE-RED FIELD STUDIES

Table C-4 - Individual Results, Sanitary Examination, Arkansas River, Mile 168.5 to 97.1 (Sheet 3 of 4)

Station	Date Sampled	Avg.Daily Flow CFS at Little Rock Arkansas	5-day B.O.D. 20°C, ppm	D.C. ppm	Temper-ature, °C.	Per Cent Saturation	Nitrates as N, ppm	PO$_4$ ppm	Cl$^-$ ppm	Turbidity ppm	Color, ppm	pH	Alkalinity ppm	Coliforms MPN per 100 ml.
Mile-126	7-14	5060	-	8.0	31	110								
	7-16	6750	-	7.1	28	90								
	7-21	5900	-	8.2	30	110								
Mile-123	7-14	5060	1.8	8.3	30	110	0.200	0.10	273	<25	5	8.3	180	-
	7-16	6750	1.3	6.9	28	88	0.070	0.08	318	45	5	8.2	180	9,300
	7-21	5900	3.3	8.4	30	110	0.050	0.14	503	27	5	8.0	164	28,000
Mile-120	7-14	5060	-	7.9	30	100								
	7-16	6750	-	7.3	29	94								
	7-21	5900	-	8.5	30	110								
Mile 115.6	7-14	5060	1.9	7.7	31	100	0.100	0.08	297	<25	5	8.1	182	-
	7-15	6500	1.9	7.7	30	100	0.100	0.08	283	27	5	7.7	185	-
	7-16	6750	1.9	6.9	29	89	0.030	0.10	319	46	5	8.1	183	4,300
	7-17	6500	2.2	6.8	28	87	0.030	0.12	321	42	10	8.3	180	9,300
	7-21	5900	2.8	8.0	30	100	0.120	0.09	480	28	5	8.0	166	2,300
	7-22	6500	2.5	7.6	30	100	0.060	0.09	522	30	5	7.9	166	91
	7-23	8150	2.6	7.4	30	98	0.120	0.08	453	31	10	8.2	142	430
Mile-112	7-14	5060	-	7.8	30	100								
	7-16	6750	-	7.1	29	91								
	7-21	5900	-	8.2	30	110								
Mile-108	7-15	6500	-	7.8	30	100								
	7-17	6500	-	6.7	28	85								

ARKANSAS-WHITE-RED FIELD STUDIES

Table C-4 - Individual Results, Sanitary Examination, Arkansas River, Mile 168.5 to 97.1 (Sheet 4 of 4)

Station	Date Sampled	Avg. Daily Flow CFS at Little Rock Arkansas	5-day B.O.D. 20° C, ppm	D.O. ppm	Temperature, °C.	Per Cent Saturation	Nitrates as N, ppm	PO_4 ppm	Cl^- ppm	Turbidity ppm	Color, ppm	pH	Alkalinity ppm	Coliforms MPN per 100 ml.
Mile 104.6	7-15	6500	1.7	8.1	30	110	0.200	0.06	282	33	5	7.9	178	-
	7-17	6500	5.1	7.8	28	99	0.030	0.14	314	36	5	8.2	180	7,500
Mile-100	7-15	6500	-	7.6	30	100								
	7-17	6500	-	7.1	28	90								
Mile-97.1	7-15	6500	1.7	7.5	30	99	0.030	0.10	273	25	10	7.8	182	-
	7-17	6500	1.9	7.0	28	88	0.020	0.14	311	40	5	8.2	185	46,000

TABLE C-5

ARKANSAS RIVER AT LITTLE ROCK, ARKANSAS

Location - Water-stage recorder, lat. 34°45', long. 92°16', in sec. 3, T. 1 N., R. 12 W., 130 feet downstream from Main Street Bridge in Little Rock. Datum of gage is 223.61 feet above mean sea level, datum of 1929.

Drainage Area - 157,933 square miles.

Average Discharge - 23 years (1927-50), 44,340 second feet.

Maximum, (1927-50) discharge, 536,000 second-feet May 27, 1943 (gage height, 30.05 feet); **minimum** discharge, 850 second feet August 23, 1934 (gage height - 4.16 feet).

Date 1952 July	Average Daily Flow cfs	Mean Velocity Ft/Sec
10	3880	
11	4180	
12	4450	
13	4450	
14*	5060	
15*	6500	1.39
16*	6750	
17*	6500	
18	5600	
19	5300	
20	5600	
21*	5900	
22*	6500	
23*	7850	
24*	8150	

Flow data obtained from Corps of Engineers.

* Days of Survey

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 1 of 3)

Table D-3 - Individual Results, Sanitary Examination - Ouachita River, Mile 418.5 to Mile 400.0

Station		Date Sampled	Avg. daily flow c.f.s. at Arkadelphia, Ark.	Coliform MPN per 100 ml		5-day B.O.D. 20°C ppm		D.O. ppm		Temperature, °C.	Per cent Saturation	Cl^- ppm	Nitrates as N ppm	PO_4^{---} ppm	Color ppm	Turbidity ppm	pH	Total Alk. ppm
		1952		Center	Left, Right	C	L, R	C	L, R									
Mile 418.5	C	7/31	190	390				6.0		30	78	9	0.015	0.020	10	< 25	6.9	34
	C	8/1	266	9,300				5.7		29	74							
Mile 418.0	C	7/28	214					5.9		30	77	9	.040	.090	15	< 25	6.8	[illegible]
	C	7/30	202	430		0.9		6.8		30	90	8	.020	.030	15	< 25	6.8	34
	C	7/31	190	230		2.3		6.0		30	78	9	.015	.020	10	< 25	6.9	32
1/4 pt. from R. Bank		8/1	266						(R)5.8	29	(R)75							
	C	8/1	266	1,500				5.7		29	73							
1/4 pt. from L. Bank		8/1	266						(L)5.7	29	(L)74							
	C	8/2	258	230		0.3		6.0		29	77	8	.015	.030	15	< 25	6.9	38
Mile 417.0																		
1/4 pt. from R. Bank		7/31	190				(R)0.7		(R)5.8	30	(R)77							
	C	7/31	190	430		0.5		5.9		30	78							
1/4 pt. from L. Bank		7/31	190		(L) 91		(L)0.6		(L)5.9	30	(L)78							
1/4 pt. from R. Bank		8/1	266		(R) 24,000				(R)5.7	29	(R)73							
	C	8/1	266	430				5.7		29	74							
1/4 pt. from L. Bank		8/1	266		(L) 4,300				(L)5.8	29	(L)74							
1/4 pt. from R. Bank		8/2	258		(R) 360		(R)0.2		(R)5.7	29	(R)73							
	C	8/2	258	430		0.3		5.8		30	76	8	.013	.030	15	< 25	6.9	36
1/4 pt. from L. Bank		8/2	258		(L) 230		(L)0.3		(L)5.7	29	(L)74							
Mile 416	C	7/31	190	150		0.6		6.1		30	80	10	.015	.020	5	< 25	6.9	35
	C	8/1	266	430				5.9		30	78							
	C	8/2	258	430		0.5		5.8		30	76	10	.030	.020	10	< 25	6.9	38

C - Centerline

ARKANSAS-WHITE-RED FIELD STUDIES

Table D-3 - Individual Results, Sanitary Examination - Ouachita River, Mile 418.5 to Mile 400.0 (Sheet 2 of 3)

Station	Date Sampled 1952	Avg. daily flow c.f.s. at Arkadelphia, Ark.	Coliform MPN per 100 ml Center	Coliform MPN per 100 ml Left, Right	5-day B.O.D. 20°C ppm C	5-day B.O.D. 20°C ppm L, R	D.O. ppm C	D.O. ppm L, R	Temperature, °C.	Per cent Saturation	Cl⁻ ppm	Nitrates as N, ppm	PO_4^{---} ppm	Color, ppm	Turbidity ppm	pH	Total Alk., ppm
Mile 415 C	7/30	202	43,000				6.3		31	84							
1/4 pt. from R Bank	7/31	190		(R) 43,000		(R)1.2		(R)6.3	30	(R)82							
C	7/31	190	93,000		0.8		6.2		30	81	11	0.015	0.030	10	< 25	6.9	33
1/4 pt. from L Bank	7/31	190		(L) 93,000		(L)0.9		(L)6.3	31	(L)83							
1/4 pt. from R Bank	8/1	266		(R) 39,000				(R)5.7	30	(R)75							
C	8/1	266	43,000				5.8		30	76							
1/4 pt. from L Bank	8/1	266		(L) 93,000				(L)5.8	30	(L)76							
1/4 pt. from R Bank	8/2	258		(R)240,000		(R)0.5		(R)5.8	30	(R)76							
C	8/2	258	20,000		0.3		5.9		30	77	13	.030	.010	10	< 25	6.9	34
1/4 pt. from L Bank	8/2	258		(L) 23,000		(L)0.4		(L)5.8	30	(L)76							
Mile 414																	
1/4 pt. from R Bank	7/31	190		(R)430,000		(R)0.8		(R)5.7	30	(R)75							
C	7/31	190	75,000		1.0		5.7		30	74							
1/4 pt. from L Bank	7/31	190		(L) 75,000		(L)0.7		(L)5.7	30	(L)75							
1/4 pt. from R Bank	8/1	266		(R)240,000				(R)5.3	30	(R)69							
C	8/1	266	240,000				5.5		30	72							
1/4 pt. from L Bank	8/1	266		(L) 93,000				(L)5.7	30	(L)74							

C - Centerline

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 3 of 3)

Table D-3 - Individual Results, Sanitary Examination - Ouachita River, Mile 418.5 to Mile 400.0

Station		Date Sampled	Avg. daily flow C.F.S. at Arkadelphia, Ark.	Coliform MPN per 100 ml			5-day B.O.D. 20°C ppm			D.O. ppm			Temperature, °C	Per cent Saturation	Cl^- ppm	Nitrates as N, ppm	PO_4^{---} ppm	Color, ppm	Turbidity ppm	pH	Total Alk., ppm
		1952		Center	Left	Right	C	L	R	C	L	R									
Mile 413	C	7/28	214							6.7			31	89	11	0.020	0.080	15	< 25	6.9	35
	C	7/30	202	150,000			0.6			6.0			31	80	10	.020	.020	15	< 25	6.8	35
Mile 410	C	7/28	214	93,000						6.7			31	89							
	C	7/30	202				0.7			6.8			31	90							
Mile 407	C	7/28	214							6.0			31	81							
	C	7/30	202				1.0			6.8			31	90							
Mile 404	C	7/28	214							7.7			32	100							
	C	7/30	202							7.9			32	110	10	.020	.020	10	< 25	6.9	33
Mile 400	C	7/28	214							8.3			32	110	10	.030	.030	15	< 25	6.9	34
	C	7/30	202				0.3			7.8			32	100	9	.020	.020	15	< 25	6.9	32

C - Centerline

Table D-4 - Ouachita River at Arkadelphia, Ark.

Location: Water-stage recorder, lat. 34° 07' 16", long. 93° 02' 46", on line between secs. 16 and 21, T. 7 S., R. 19 W., at bridge on State Highway 51, at Arkadelphia, Clark County. Datum of gage is 160.301 feet above mean sea level, datum of 1929.

Drainage Area: 2,311 square miles.

Mean Annual Runoff: 20.52 inches, or 2,529,000 acre-feet.

Average Discharge, 20 years (1905-06, 1929-48), 3,493 second-feet. **Maximum**,(1905-06, 1929-48), discharge 222,000 second-feet March 30,1945 (gage height 30.3 feet). **Minimum** (1905-06, 1929-48): **day**, 62 second-feet (40.0 MGD) Aug.8,1937; **7-day** 93.7 second-feet (60.6 MGD) Aug.13-19, 1937; **calendar month** 113 second-feet (73.0 MGD) August,1930; **water year** 1,442 second-feet (932 MGD) Oct.1,1935, to Sept.30,1936.

Date 1952 July	Average Daily Flow, cfs	Mean Velocity ft/sec	Date 1952 August	Average Daily Flow, cfs	Mean Velocity ft/sec
15	262		1*	266	
16	270	1.53	2*	258	
17	330		3	250	
18	326		4	250	
19	330		5	286	
20	338		6	400	
21	318		7	430	1.79
22	294		8	314	
23	278		9	310	
24	262		10	306	
25	238		11	306	
26	210		12	385	1.84
27	214		13	302	
28*	214		14	230	
29*	190		15	270	
30*	202	1.50			
31*	190				

* Days of survey.

ARKANSAS-WHITE-RED FIELD STUDIES

(Sheet 1 of 20)

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0

Station	Date Sampled	Ave. Daily Flow, CFS	5-day BOD 20° C. ppm	D.O. ppm	Temperature, °C.	Per Cent Saturation	Cl⁻ ppm		Nitrates as N, ppm	PO_4 ppm	Color, ppm	Turbidity ppm	pH	Total Alkalinity, ppm	Coliforms MPN per 100 ml.
							3'	Depth							
Mile 351 C	8/5	822	0.2	6.1	30	80	18		0.015	0.070	20	<25	6.7	23	390
C	8/6	800	1.3	6.5	29	83	12		0.015	0.040	25	42	6.7	24	110,000
C	8/7	776	0.5	6.5	29	84	12		0.010	0.006	20	25	6.8	21	4,300
C	8/8	793	0.3	6.6	30	86	9		0.020	0.004	25	25	6.7	25	4,300
C	8/11	1150	0.4	6.9	30	90	27		0.030	0.030	20	25	6.9	28	360
C	8/12	820	0.6	6.7	30	88	15		0.015	<0.002	20	27	6.9	28	430
C	8/14	690	0.6	6.9	31	92	30		-	0.002	25	<25	7.0	32	1,500
1/4 Pt. from R. Bank	8/16	778					(R) 41								
3/8 Pt. from R. Bank	8/16						(R) 41								
C top - 3 ft.	8/16						41								
3/8 Pt. from L. Bank	8/16						(L) 41								
1/4 Pt. from L. Bank	8/16						(L) 41								
C Bottom	8/16						(L) 41	41							
Mile 345 C	8/6		0.5	6.0	29	77	16		0.012	0.140	20	112	6.6	25	24,000
C	8/8		0.4	6.1	28	78	11		0.008	0.010	25	29	6.8	25	7,500
C	8/15		0.6	6.8	30	89	31		-	0.030	20	<25	6.8	29	24,000
C	8/19		0.4	6.2	32	84	61		-	-	-	-	-	-	-
C (8')	8/19							(8') -58							
C (13')	8/19							(13') -58							
C (14')	8/19							(14') -58							
C	8/20		0.1	5.9	30	77	25		-	-	-	-	-	-	-
C (8')	8/20							(8') -24							
C (13')	8/20							(13') -25							
C (18')	8/20							(18') -25							
C (19')	8/20							(19') -25							

C = Centerline

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 2 of 20)

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0

Station	Date Sampled	Ave. Daily Flow, CFS	5-day BOD 20° C. ppm	D.O. ppm	Temperature, °C.	Per Cent Saturation	Cl^- ppm 3'	Cl^- ppm Depth	Nitrates as N, ppm	PO_4 ppm	Color, ppm	Turbidity ppm	pH	Total Alkalinity, ppm	Coliforms MPN per 100 ml
Mile 344 C	8/6		0.4	5.9	29	76	20		0.010	0.180	15	50	6.7	24	9,300
East Two Bayou C	8/8		0.7	6.0	29	78	10		0.350	0.006	25	40	6.7	24	9,300
C	8/15		0.6	6.7	30	88	33		-	0.036	20	<25	6.8	29	7,500
C	8/19		0.5	6.3	31	84	50		-	0.080	30	<25	6.9	37	4,300
C	8/20		0.3	6.2	30	81	32		-	<0.002	20	<25	6.9	34	24,000
West Two Bayou C	8/6		88	0	32	0	123		8.000	<0.002	250	182	7.2	175	9,300
	8/8		76	0	32	0	34		7.000	0.010	150	245	6.9	157	2,900
	8/15		74	0	30	0	79		2.000	0.010	75	380	6.7	95	<360
	8/19		92	0	36	0	61		-	<0.002	375	200	7.3	230	430
	8/20		80	0	33	0	58		-	0.004	200	125	7.1	183	4,300
Mile 342.5 C	8/8		2.2	4.0	29	51	-		-	-	-	-	-	-	-
Mile 341 C	8/6		1.3	4.2	30	55	33		0.020	0.014	25	28	6.8	33	43,000
C	8/8		2.4	3.8	29	49	11		0.012	0.020	35	28	6.8	32	9,300
C	8/15		1.9	4.6	30	60	39		-	0.026	25	30	6.8	28	2,300
C	8/20		-	4.2	30	56	52		-	-	-	-	-	-	-
C (8')	8/20							(8')-52							
C (9')	8/20							(9')-52							
Mile 336 C	8/6		2.0 (2)	4.3	30	54	16		0.012	0.016	25	32	6.9	32	2,300
C	8/7		2.4 (1)	3.8	30	50	32		0.014	0.006	25	31	6.8	28	930
C			3.3 (2)	1.6	30	21	19		0.050	0.006	35	27	6.8	35	2,300
C	8/12		1.2	4.4	30	58	15		0.015	0.006	25	30	6.9	34	750
C	8/19		0.9	4.4	32	59	37		-	-	-	-	-	-	-
C (8')	8/19							(8')-35							
C (12')	8/19							(12')-35							

C = Centerline (1) 50% dilution (2) 25% dilution

(Sheet 3 of 20)

ARKANSAS-WHITE-RED FIELD STUDIES

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0

Station	Date Sampled	Ave.Daily Flow,CFS	5-day BOD 20°C. ppm	D.O. ppm	Temperature,°C.	Per Cent Saturation	Cl⁻ ppm		Nitrates as N,ppm	PO_4 ppm	Color,ppm	Turbidity ppm	pH	Total Alkalinity,ppm	Coliforms MPN per 100 ml.
							3'	Depth							
Mile 330 C	8/12		0.7	4.0	30	53	11		0.015	0.004	25	26	6.8	30	930
Mile 325 C	8/7		$1.5^{(1)}$	3.6	30	48	28		0.030	0.010	30	<25	6.9	33	91
C	8/12		0.5	3.9	30	51	10		0.020	0.060	25	25	6.8	26	150
Mile 319 C	8/7		$1.4^{(1)}$	3.5	30	46	18		0.025	0.040	30	<25	7.0	38	73
C	8/12		0.7	3.1	31	41	20		*	0.040	25	<25	6.9	30	280
C	8/18		-	5.1	32	69	19		-	0.002	25	<25	6.8	27	91
C (8')	8/18				31			(8')-18							
C (13')	8/18							(13')-17							
C (18')	8/18							(18')-15							
Mile 313															
1/4 Pt.from R.Bank	8/14						(R) 18								
C	8/14		-	4.3	32	58	17		-	-	-	-	-	-	-
1/4 Pt.from L.Bank	8/14						(L) 18								
C Bottom (13')	8/14							(13')-2150							
C	8/18		-	4.6	32	63	17		-	-	-	-	-	-	-
C (8')	8/18							(8')- 45							
C (12')	8/18							(12')-100							
Smackover Creek C	8/14		1.0	4.8	32	65	24		0.030	0.026	20	<25	6.8	31	150
C	8/18		0.7	5.2	33	72	52		-	0.002	20	<25	6.9	29	2,100

C = Centerline (1) 50% dilution (2) 25% dilution *Off color - No reading

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 4 of 20)

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0

Station	Date Sampled	Ave. Daily Flow, CFS	5-day BOD 20°C, ppm	D.O. ppm	Temperature °C	Per Cent Saturation	Cl^- ppm		Nitrates as N, ppm	PO_4 ppm	Color, ppm	Turbidity ppm	pH	Total Alkalinity, ppm	Coliforms MPN per 100 ml.
							3'	Depth							
Mile 310															
1/4 Pt. from R. Bank	8/14						(R) 38								
C	8/14			4.9	30	56	30								
1/4 Pt. from L. Bank	8/14						(L) 33								
C (16')	8/14							(16')-2180							
Mile 309															
1/4 Pt. from R. Bank	8/14						(R) 38								
C	8/14		-	4.8	31	44	35								
1/4 Pt. from L. Bank	8/14						(L) 33								
C (14')	8/14				32			(14')-2790							
Champagnolle Cr.	8/15		0.5(1)	5.2	31	65	55		-	0.018	25	<25	6.9	28	36
Mile 308 C	8/5		3.0(1)	3.7	30	49	67		0.024	0.050	30	<25	6.9	38	210
	8/6		4.2(2)	3.8	29	49	123		0.024	0.040	30	<25	6.9	35	110,000
1/4 Pt. from R. Bank	8/7				30		(R) 129								
C	8/7		5.6(1)	3.4	30	45	120		0.015	0.010	30	<25	6.9	43	110,000
1/4 Pt. from L. Bank	8/7				30		(L) 124								
1/4 Pt. from R. Bank	8/8				30		(R) 105								
C	8/8		4.6(2)	3.3	30	45	89		0.035	0.006	20	<25	6.9	39	910
1/4 Pt. from L. Bank	8/8				30		(L) 99								
1/4 Pt. from R. Bank	8/11				31		(R) 136								
C	8/11		5.3(1)	3.7	31	50	174		0.015	0.080	20	25	6.9	38	< 360
1/4 Pt. from L. Bank	8/11				31		(L) 150								
C	8/12		0.4	4.8	31	63	185		0.120	<0.002	20	<25	6.9	34	230
C	8/14		5.1	3.6	31	48	223		0.200	0.002	15	27	6.9	33	230

C = Centerline. (1) 50% dilution (2) 25% dilution

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 5 of 20)

Table E-4 -- Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0

Station	Date Sampled	Ave. Daily Flow, CFS	5-day BOD 20° C. ppm	D.O. ppm	Tempera-ture, °C.	Per Cent Saturation	Cl^- ppm		Nitrates as N, ppm	PO_4 ppm	Color, ppm	Turbidity ppm	pH	Total Alka-linity, ppm	Coliforms MPN per 100 ml.
							3'	Depth							
Mile 308 (Cont'd)															
1/4 Pt. from R. Bank	8/16						(R) 72								
3/8 Pt. from R. Bank	8/16						(R) 43								
C	8/16						43								
3/8 Pt. from L. Bank	8/16						(L) 50								
1/4 Pt. from L. Bank	8/16						(L) 62								
Bottom (17')	8/16							(17')-7410							
Chapelle Slough	8/14		1.8	5.4	31	72	155		-	-	-	-	-	-	-
Mile 305															
1/4 Pt. from R. Bank	8/14						(R) 146								
C	8/14		1.6(1)	5.7	31	76	192		0.100	0.030	15	<25	6.9	31	430
1/4 Pt. from L. Bank	8/14						(L) 144								
C Bottom (15')	8/14							(15')-5160							
C	8/18		-	5.7	33	78	55								
C (13')	8/18							(13')- 92							
C (18')	8/18							(18')-7370							
C (23')	8/18							(23')-7310							
Mile 303.5															
1/4 Pt. from R. Bank	8/14						(R) 166								
C	8/14		-	5.7	31	76	184		-	-	-	-	-	-	-
1/4 Pt. from L. Bank	8/14						(L) 169								
C Bottom (15')	8/14							(15')-5990							

C = Centerline (1) 50% dilution (2) 25% dilution

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 6 of 20)

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0

Station	Date Sampled	Ave.Daily Flow,CFS	5-day BOD 20° C. ppm	D.O. ppm	Tempera-ture, °C.	Per Cent Saturation	Cl⁻ ppm 3'	Cl⁻ ppm Depth	Nitrates as N,ppm	PO₄ ppm	Color,ppm	Turbidity ppm	pH	Total Alkalinity,ppm	Coliforms MPN per 100 ml.
Mile 301															
1/4 Pt.from R.Bank	8/14						(R) 196								
C	8/14		-	6.0	32	81	197		-	-	-	-	-	-	-
1/4 Pt.from L.Bank	8/14						(L) 196								
C Bottom (12')	8/14							(12')-5110							
Mile 299															
1/4 Pt.from R.Bank	8/14						(R) 257								
C	8/14		-	5.9	32	80	255		-	-	-	-	-	-	-
1/4 Pt.from L.Bank	8/14						(L) 251								
C Bottom (15')	8/14							(15')-3800							
Mile 298															
1/4 Pt.from R.Bank	8/14						(R) 301								
C	8/14		0.2	5.6	32	76	299		0.100	0.020	15	<25	6.9	37	<36
1/4 Pt.from L.Bank	8/14						(L) 302								
C Bottom(12')	8/14							(12')-419							
Mile 297.6															
C	8/19		1.0	5.5	33	76	-		-	-	-	-	-	-	-
C (8')	8/19							(8')-159							
C (13')	8/19							(13')-317							
C (18')	8/19							(18')-4910							
C (23')	8/19							(23')-5060							

C = Centerline

(Sheet 7 of 20)

ARKANSAS-WHITE-RED FIELD STUDIES

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0

Station	Date Sampled	Ave. Daily Flow, CFS	5-day BOD 20° C., ppm	D.O. ppm	Tempera-ture, °C.	Per Cent Saturation	Cl⁻ ppm 3'	Cl⁻ ppm Depth	Nitrates as N, ppm	PO_4 ppm	Color, ppm	Turbidity ppm	pH	Total Alka-linity, ppm	Coliforms MPN per 100 ml.
Mile 256 C	8/18		-	6.1	32	82	801		-	-	-	-	-	-	-
C (8')	8/18							(8') 801							
C (12')	8/18							(12') 795							
Saline River C	8/18	-	0.9	5.7	32	77	188		-	0.014	15	<25	7.0	36	230
C(15')	8/18							(15') 764							
Mile 251 C	8/5		1.9	8.9	32	120	835		0.070	0.040	10	<25	6.9	27	930
C	8/6		1.3	8.4	31	110	869		0.080	0.006	10	<25	6.9	30	15,000
C	8/7		0.8	7.3	30	96	928		0.040	0.004	20	<25	6.9	36	15,000
C	8/8		0.4	7.0	30	91	927		0.100	0.002	10	<25	6.9	34	91
C	8/11		0.3	6.0	30	79	960		0.120	0.004	15	25	6.9	33	360
C	8/13		1.7	7.0	31	93	827		0.100	<0.002	10	<25	7.0	37	2,400
C	8/14		2.2	5.5	31	73	778		0.100	0.006	10	<25	6.9	40	430
C	8/18		0.8	6.8	32	92	415		-	-	-	-	-	-	-
C (8')	8/18							(8') 759							
C (13')	8/18							(13') 755							
C (18')	8/18							(18') 825							
C (20')	8/18							(20') 801							
La Pille Creek C	9/18	-	0.9	7.2	31	96	704		-	<0.002	15	<25	7.0	37	<36
Mile 238 C	8/20		1.5	7.2	32	97	728		-	-	-	-	-	-	-
C (8')	8/20							(8') 740							
C (13')	8/20							(13') 776							
C (18')	8/20							(18') 764							

C = Centerline

ARKANSAS-WHITE-RED FIELD STUDIES

(Sheet 8 of 20)

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0

Station	Date Sampled	Ave. Daily Flow, CFS	5-day BOD 20°C. ppm	D.O. ppm	Tempera-ture, °C.	Per Cent Saturation	Cl^- ppm		Nitrates as N, ppm	PO_4 ppm	Color, ppm	Turbidity ppm	pH	Total Alka-linity, ppm	Coliforms MPN per 100 ml.
							3'	Depth							
Mile 237.5															
1/4 Pt. from R. Bank	8/11		(R)2.0	(R)8.3	32	(R)110			-	-	-	-	-	-	-
C	8/11		2.0	8.3	32	110	881		0.050	0.004	10	<25	6.9	25	91
1/4 Pt. from L. Bank	8/11		(L)2.1	(L)8.3	31	(L)110			-	-	-	-	-	-	-
1/4 Pt. from R. Bank	8/13		(R)1.7	(R)7.4	30	(R) 98			-	-	-	-	-	-	-
C	8/13		1.2	7.5	30	98	886		0.100	<0.002	10	<25	6.9	32	390
1/4 Pt. from L. Bank	8/13		(L)1.7	(L)7.9	30	(L)100			-	-	-	-	-	-	-
1/4 Pt. from R. Bank	8/15		-	(R)7.8	31	(R)100			-	-	-	-	-	-	-
C	8/15		1.5	8.1	31	110	901		-	<0.002	10	<25	6.8	30	91
1/4 Pt. from L. Bank	8/15		-	(L)8.1	31	(L)110			-	-	-	-	-	-	-
C	8/19		0.7	6.7	32	90	837		-	0.020	10	<25	6.9	41	36
C	8/20		1.1	6.8	33	93	747		-	0.010	10	<25	6.9	35	-
C (8')	8/20							(8) 747							
C (11')	8/20							(11) 445							
Outlet from Mossy C	8/11		9.3	0	33	0	130		6.000	<0.002	500	95	7.5	352	1,500
Lake C	8/13		21	0.1	31	0.9	108		7.000	<0.002	375	120	7.5	364	15,000
C	8/15		13	0	31	0	110		-	0.014	500	100	7.4	368	430
C	8/19		24	0	30	0	97		-	0.024	375	130	7.6	385	430
C	8/20		16	0	31	0	100		-	0.010	375	85	7.7	380	930
Mile 235.5															
1/4 Pt. from R. Bank	8/11		(R)2.1	(R)8.2	31	(R)110			-	-	-	-	-	-	-
C	8/11		2.1	8.1	31	110	610		0.030	<0.002	10	<25	7.0	34	150
1/4 Pt. from L. Bank	8/11		(L)2.7	(L)8.6	31	(L)110			-	-	-	-	-	-	-
1/4 Pt. from R. Bank	8/13		(R)1.5	(R)7.2	31	(R)100			-	-	-	-	-	-	-
C	8/13		1.5	7.3	31	97	887		0.120	0.006	15	28	7.0	36	91

C = Centerline

ARKANSAS-WHITE-RED FIELD STUDIES

(Sheet 9 of 20)

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0

Station	Date Sampled	Ave.Daily Flow,CFS	5-day B.O.D. 20°C, ppm	D.O. ppm	Tempera-ture, °C.	Per Cent Saturation	Cl⁻ ppm		Nitrates as N, ppm	PO_4 ppm	Color,ppm	Turbidity ppm	pH	Total Alka-linity,ppm	Coliforms MPN per 100 ml.
							3'	Depth							
Mile 235.5 (Cont'd)															
1/4 Pt.from L.Bank	8/13		(L) 0.8	(L)6.8	31	(L) 90			-	-	-	-	-	-	-
1/4 Pt.from R.Bank	8/15			(R)7.3	31	(R) 97									
C	8/15			7.3	31	98	882		-	<0.002	15	<25	6.9	38	36
1/4 Pt.from L.Bank	8/15			(L)7.3	31	(L) 97									
C	8/19		1.0	6.3	31	84	831		-	0.020	15	<25	6.9	42	150
C (8')	8/19							(8') 831							
C (10')	8/19							(10') 832							
C	8/20		1.2	6.5	32	88	755			0.004	10	25	7.0	42	430
C (8')	8/20							(8') 764							
C (10')	8/20							(10')768							
Mile 235.5															
1/4 Pt.from R.Bank	8/26		(R) 1.6	(R) 6.7	32	91	-	-	-	-	-	-	-	-	-
C	8/26		1.2	6.2	32	83	728		0.100	<0.002	20	<25	7.0	40	91
1/4 Pt.from L.Bank	8/26		(L) 1.4	(L) 6.2	32	84	-		-	-	-	-	-	-	-
C Bottom (12')	8/26		-	(12') 6.3	32	85		(12')716							
1/4 Pt.from R.Bank	8/28		-	(R) 7.0	31	93	(R)701		-	-	-	-	-	-	-
C	8/28		1.3	6.8	32	92	698		0.100	0.014	15	<25	7.2	37	36
1/4 Pt.from L.Bank	8/28		-	(L) 6.6	31	88	(L)693		-	-	-	-	-	-	-
C Bottom (10')	8/28		-	(10')6.1	31	82		(10')698	-	-	-	-	-	-	-
1/4 Pt.from R.Bank	9/2		-	(R) 6.6	29	84	(R)764		-	-	-	-	-	-	-
C	9/2		1.3	6.6	29	84	769		0.080	0.002	20	<25	7.2	43	930
1/4 Pt.from L.Bank	9/2			(L) 6.5	29	84	(L)769		-	-	-	-	-	-	-
C Bottom (10')	9/2		-	(10')6.1	28	77		(10')761	-	-	-	-	-	-	-
C	9/4		2.3	7.9	29	100	770		0.030	0.002	15	<25	7.3	40	91
C	9/8		1.9	7.0	30	91	671		0.100	<0.002	15	<25	7.1	38	930

C = Centerline

ARKANSAS-WHITE-RED FIELD STUDIES

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0 (Sheet 10 of 20)

Station	Date Sampled	Ave. Daily Flow, CFS	5-Day B.O.D. 20°C., ppm	D.O. ppm	Temperature, °C.	Per Cent Saturation	Cl⁻ ppm 3'	Cl⁻ ppm Depth	Nitrates as N, ppm	PO_4 ppm	Color, ppm	Turbidity ppm	pH	Total Alkalinity, ppm	Coliforms MPN per 100 ml.
Mile 224.5															
1/4 Pt. from R. Bank	8/26		(R) 1.8	(R)7.4	31	98	-		-	-	-	-	-	-	-
C	8/26		1.9	7.7	32	100	694		0.100	0.030	15	<25	7.0	38	36
1/4 Pt. from L. Bank	8/26		(L) 1.4	(L)7.1	32	96			-	-	-	-	-	-	-
C Bottom (15')	8/26		-	(15')7.8	32	110		(15')700	-	-	-	-	-	-	-
1/4 Pt. from R. Bank	8/28		-	(R) 6.9	31	92	(R) 724		-	-	-	-	-	-	-
C	8/28		1.0	6.4	31	86	724		0.100	<0.002	10	<25	7.2	41	91
1/4 Pt. from L. Bank	8/28		-	(L) 6.6	31	87	(L) 723		-	-	-	-	-	-	-
C (8')	8/28		-	(8)6.2	31	83		(8') 723	-	-	-	-	-	-	-
1/4 Pt. from R. Bank	9/2		-	(R)6.3	29	81	(R)699		-	-	-	-	-	-	-
C	9/2		0.8	6.2	29	80	698		0.030	<0.002	10	<25	7.2	41	150
1/4 Pt. from L. Bank	9/2		-	(L)6.5	29	84	(L)698		-	-	-	-	-	-	-
C (12')	9/2		-	(12')6.2	29	80		(12')704	-	-	-	-	-	-	-
	9/4		0.9	5.9	28	74	733		0.100	0.004	15	<25	7.3	42	230
	9/8		0.9	6.8	29	88	767		0.030	0.002	15	<25	7.1	36	230
Mile 206.7															
C (12')	8/26		-	(12')6.8	29	88		(12')710	-	-	-	-	-	-	-
C	8/27		0.8	7.0	32	94	752		0.050	0.040	15	<25	7.1	47	930
C (8')	8/27		-	-	-	-		(8')764							
C (11')	8/27							(11')772							
C	8/29		0.7	6.6	32	90	700		0.300	0.004	10	<25	7.4	46	930
C (8')	8/29							(8') 710							
C (13')	8/29							(13')704							
C	9/4		0.4	6.7	30	89	603		0.030	<0.002	15	<25	7.4	52	930
C	9/9		0.6	7.1	31	94	585		0.120	0.004	15	<25	7.3	53	4,300

C = Centerline

ARKANSAS-WHITE-RED FIELD STUDIES

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0 (Sheet 11 of 20)

Station	Date Sampled	Ave. Daily Flow, CFS	5-day B.O.D. 20°C, ppm	D.O. ppm	Tempera-ture, °C.	Per Cent Saturation	Cl^- ppm		Nitrates as N, ppm	PO_4 ppm	Color, ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml.
							3'	Depth							
Bayou de Loutre															
C	8/26		1.5	4.0	30	52	493		0.100	<0.002	25	<25	6.9	51	-
C 6'	8/26							(6') 417							
C	8/27		1.9	5.6	30	74	497		0.070	<0.002	35	27	7.0	51	-
C	8/28		2.3	6.6	30	87	582		0.100	<0.002	25	<25	7.3	52	-
C	8/29		2.0	6.7	29	86	560		-	-	-	-	-	-	-
C	9/2		2.5	8.4	30	110	580		0.030	0.010	20	<25	7.5	52	230
C	9/4		1.6	5.4	30	71	576		0.070	<0.002	20	<25	7.1	52	430
Mile 195															
C	8/26		1.2	6.2	32	84	755		0.100	0.004	10	<25	7.0	42	2100
C 8'	8/26				32			(8') 752							
C 12'	8/26				32			(12') 752							
C	8/27		1.5	6.6	32	89	704		0.050	0.004	15	25	7.1	49	430
C 8'	8/27							(8') 707							
C	8/28		1.2	5.2	32	70	704		0.100	0.004	15	<25	7.3	52	390
C 8'	8/28							(8') 704							
C	8/29		1.3	5.4	32	73	709		0.300	0.002	10	<25	7.3	52	230
C 8'	8/29							(8') 706							
C	9/2		1.3	6.5	31	86	716		0.030	0.004	10	<25	7.3	44	290
C 8'	9/2							(8') 710							
C 10'	9/2							(10') 711							
C	9/4		1.3	6.8	29	87	616		0.050	<0.002	15	27	7.4	49	73
C	9/9		1.1	6.4	30	84	607		0.030	<0.002	15	25	7.2	50	150

C = Centerline

ARKANSAS-WHITE-RED FIELD STUDIES

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0 (Sheet 12 of 20)

Station	Date Sampled	Ave. Daily Flow, CFS	5-day B.O.D. 20°C, ppm	D.O. ppm	Tempera- ture, °C.	Per Cent Saturation	Cl⁻ ppm 3'	Cl⁻ ppm Depth	Nitrates as N, ppm	PO_4 ppm	Color, ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml
Bayou D'Arbonne															
C	8/26		1.2	5.6	31	75	788		0.120	0.006	10	<25	6.8	27	-
C 8'	8/26							(8') 724							
C 13'	8/26							(13')1102							
C	8/27		1.7	7.8	31	100	752								
C 8'	8/27							(8') 704							
C 13'	8/27							(13') 698							
C 16'	8/27							(16') 716							
C	8/28		1.4	5.9	31	79	546								
C 8'	8/28							(8') 562							
C 13'	8/28							(13') 638							
C 16'	8/28							(16') 622							
C	8/29		1.6	6.2	30	81	440								
C 8'	8/29							(8') 461							
C 13'	8/29							(13') 443							
C 16'	8/29							(16') 461							
C	9/2		1.4	6.8	30	89	687		0.030	<0.002	10	<25	7.3	46	-
C 8'	9/2							(8') 599							
C 13'	9/2							(13') 507							
C	9/4		1.4	6.1	28	77	631								
Mile 179.1															
C	8/26	1080*	1.8	6.5	32	88	594		0.100	0.004	10	<25	7.0	43	93,000
C 8'	8/26							(8') 586							
C 13'	8/26							(13') 591							
C 17'	8/26							(17') 582							
C	8/27	1040	1.6	6.8	32	91	607		0.050	0.002	10	<25	7.0	44	240,000
C 8'	8/27							(8') 603							

C = Centerline * Estimated

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 13 of 20)

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0

Station	Date Sampled	Ave.Daily Flow, CFS	5-day B.O.D. 20°C, ppm	D.O. ppm	Tempera-ture, °C.	Per Cent Saturation	Cl$^-$ ppm		Nitrates as N,ppm	PO$_4$ ppm	Color,ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml.
							3'	Depth							
Mile 179.1 (Cont'd)															
C 13'	8/27							(13') 601							
C 18'	8/27							(18') 592							
C 23'	8/27							(23') 590							
C	8/28	1015*	1.1	6.4	32	86	610		0.120	0.002	10	<25	7.3	48	7,300
C 8'	8/28							(8') 621							
C 13'	8/28							(13') 608							
C 18'	8/28							(18') 615							
C 23'	8/28							(23') 613							
C	8/29	990*	1.4	6.4	32	86	621		0.250	<0.002	10	<25	7.1	46	9,300
C 8'	8/29							(8') 621							
C 13'	8/29							(13') 613							
C 18'	8/29							(18') 635							
C	9/2	900*	1.0	5.8	30	76	707		0.070	0.016	10	<25	7.2	44	43,000
C 8'	9/2							(8') 718							
C 13'	9/2							(13') 730							
C 18'	9/2							(18') 723							
C	9/3	880	1.4	6.9	30	90	840		0.030	0.020	15	<25	7.2	50	9,300
C	9/4	865*	1.4	7.1	29	91									
	9/5	850*	1.2	6.8	28	86	671		0.030	0.002	10	<25	7.3	43	9,300
C Surface	9/8	805*	-	7.8	29	100									
C	9/8		1.6	7.9	29	100	738		0.030	0.004	10	<25	7.2	43	43,000
C 18'	9/3		-	6.7	28	84									
C	9/9	791	16	2.4	30	31	667		0.070	0.002	60	43	7.1	77	43,000
C Surface	9/10	785*	-	7.3	28	91									
C	9/10		-	7.2	28	92									
C 18'	9/10		-	5.9	28	74									

C = Centerline * Estimated

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 14 of 20)

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0

Station	Date Sampled	Ave. Daily Flow, CFS	5-day B.O.D. 20°C, ppm	D.O. ppm	Tempera-ture, °C.	Per Cent Saturation	Cl^- ppm		Nitrates as N, ppm	PO_4 ppm	Color, ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml.
							3'	Depth							
Mile 178.8															
C Surface	9/8		-	4.9	28	61									
C 3'	9/8		1.6	6.2	28	78									
C 6'	9/8		-	6.2	28	78									
C 9'	9/8		-	6.1	28	77									
C 12'	9/8		-	6.2	28	78									
C 15'	9/8		-	6.1	28	77									
C 18'	9/8			5.8	28	73									
Mile 178.7															
C Surface	9/8		-	0	32	0									
C 3'	9/8		3.6	3.8	28	48									
C 6'	9/8		-	2.3	28	29									
C 9'	9/8		-	2.5	28	32									
C 12'	9/8		-	3.8	28	47									
C 15'	9/8		-	5.4	28	68									
C 19'	9/8		-	4.8	28	61									
C 3'	9/10		-	0	29	0									
Black Bayou C	9/2		64	0	28	0	570		0.050	0.004	40	1225	8.6	350	-
(Depth 1' C	9/3		185	0	36	0	861		0.700	<0.002	625	220	9.8#	420	
all samples) C	9/4		95	0	32	0	516		0.700	<0.002	200	101	9.5	132	
C	9/5		28	5.3	30	70	653		0.070	0.006	30	175	7.6	97	
C	9/8		230	0	36	0	393		1.000	<0.002	500	266	7.8	286	
C	9/9		209	0	38	0	291		1.000	<0.002	625	280	9.0	369	
C	9/10		-	0	29	0									

C = Centerline

Est.

ARKANSAS-WHITE-RED FIELD STUDIES

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0 (Sheet 15 of 20)

Station	Date Sampled	Ave.Daily Flow, CFS	5-day B.O.D. 20°C, ppm	D.O. ppm	Tempera-ture, °C.	Per Cent Saturation	Cl^- ppm		Nitrates as N,ppm	PO_4 ppm	Color,ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml.
							3'	Depth							
Mile 178.6															
1/4 Pt.from R.Bank 3'	9/5		-	(R) 6.4	29	(R) 82									
C 3'	9/5		1.2	6.3	28	80									
1/4 Pt.from L.Bank 3'	9/5		-	(L) 6.4	29	(L) 83									
C 6'	9/5		-	6.2	28	79									
C 9'	9/5		-	6.2	28	78									
1/4 Pt.from L.Bank 11'	9/5			(L) 5.8	28	(L) 74									
C 12'	9/5			6.0	28	76									
C 15'	9/5			6.0	28	76									
1/4 Pt.from R.Bank 15'	9/5			(R) 5.7	28	(R) 72									
C 18'	9/5			6.0	28	76									
C 22'	9/5		2.0	5.8	28	73									
Mile 178.6															
C Surface	9/8			0	34	0									
C 3'	9/8			0	30	0									
C 6'	9/8			0	29	0									
C 9'	9/8			0	28	0									
C 12'	9/8			1.4	28	18									
C 15'	9/8			2.8	28	35									
C 18'	9/8			4.2	28	54									
C 3'	9/10			0	29	0									

C = Centerline

ARKANSAS-WHITE-RED FIELD STUDIES

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0 (Sheet 16 of 20)

Station	Date Sampled	Ave.Daily Flow, CFS	5-day B.O.D. 20°C, ppm	D.O. ppm	Te[illegible]ture	Per Cent Saturation	Cl⁻ ppm 3'	Cl⁻ ppm Depth	Nitrates as N, ppm	PO_4 ppm	Color, ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml.
Mile 178															
1/4 Pt.from R.Bank 3'	9/5			(R) 4.2	28	(R) 53									
C 3'	9/5		Septic	3.0	29	39									
1/4 Pt.from L.Bank 3'	9/5			(L) 2.6	29	(L) 33									
C 6'	9/5			3.2	28	41									
1/4 Pt.from L.Bank 9'	9/5			(L) 2.3	28	(L) 29									
C 9'	9/5			3.9	28	49									
C 12'	9/5			4.9	28	62									
C 15'	9/5			5.5	28	69									
C 18'	9/5		2.8	5.4	28	69									
1/4 Pt.from R.Bank 20'	9/5			(R) 5.6	28	(R) 70									
C Surface	9/8			0.2	29	3									
C 3'	9/8		15	0	28	0									
C 6'	9/8			0	28	0									
C 9'	9/8			0.1	28	2									
C 12'	9/8			2.7	28	34									
C 18'	9/8			4.7	28	59									
C Surface	9/10			3.4	29	44									
C 3'	9/10			3.2	28	41									
C 18'	9/10			3.6	28	46									

C = Centerline

ARKANSAS-WHITE-RED FIELD STUDIES

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0 (Sheet 17 of 20)

Station	Date Sampled	Ave. Daily Flow, CFS	5-day B.O.D. 20°C, ppm	D.O. ppm	Tempera-ture, °C.	Per Cent Saturation	Cl⁻ ppm		Nitrates as N, ppm	PO_4 ppm	Color, ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml.
							3'	Depth							
Mile 177.6															
C 3'	9/5		Septic	3.4	29	43									
C 6'	9/5		-	3.4	28	42									
C 9'	9/5		-	3.3	28	42									
C 12'	9/5		-	3.3	28	42									
C 15'	9/5		-	3.1	28	40									
C 18'	9/5		Septic	3.2	28	41									
C Surface	9/8		-	2.0	30	26									
C 3'	9/8		9.8	0	29	0									
C 9'	9/8		-	2.8	28	35									
C 17'	9/8		-	4.0	28	50									
Mile 177.35															
C 3'	8/28		7.7	1.2	32	16	596		0.120	<0.002	30	<25	7.0	58	75,000
C 8'	8/28							(8') 594							
C 13'	8/28							(13') 598							
C 17'	8/28							(17') 599							
C 3'	8/29		2.7	3.4	32	46	603		0.250	<0.002	20	26	7.1	52	43,000
C 8'	8/29							(8') 607							
C 13'	8/29							(13') 609							

C = Centerline

ARKANSAS-WHITE-RED FIELD STUDIES

(Sheet 18 of 20)

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0

Station		Date Sampled	Ave. Daily Flow, CFS	5-day B.O.D. 20°C, ppm	D.O. ppm	Temperature, °C.	Per Cent Saturation	Cl⁻ ppm		Nitrates as N, ppm	PO₄ ppm	Color, ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml.
								3'	Depth							
Mile 177.35 (Cont'd)																
C	18'	8/29							(18') 592							
C	3'	9/2		1.4	1.9	29	24	722		0.080	0.010	25	<25	7.2	61	3,600
C	8'	9/2							(8') 722							
C	13'	9/2							(13') 750							
C	18'	9/2							(18') 722							
C	3'	9/3		2.1	2.6	30	34	742		0.030	0.024	25	<25	7.1	51	24,000
C	3'	9/4		2.2	5.1	29	66	701		0.020	0.002	20	<25	7.3	46	-
C	16'	9/4		-	2.9	28	37									
C	3'	9/5		2.4	4.5	29	58	692		0.030	0.004	20	<25	7.3	57	9,300
C	6'	9/5		-	4.4	28	55									
C	9'	9/5		-	4.3	28	55									
C	12'	9/5		-	4.3	28	54									
C	15'	9/5		2.2	4.3	28	55									
C	Surface	9/8		-	3.3	30	43									
C	3'	9/8		3.2	1.8	28	22	716		0.070*	0.004	30	<25	7.1	56	4,300
C	9'	9/8		-	2.5	28	31									
C	17'	9/8		-	2.3	28	29									
C	3'	9/9		6.2	2.1	29	26	716		0.070*	<0.002	40	25	7.2	62	43,000

C = Centerline

* Off color.

ARKANSAS-WHITE-RED FIELD STUDIES

(Sheet 19 of 20)

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0

Station	Date Sampled	Ave.Daily Flow, CFS	5-day B.O.D. 20°C, ppm	D.O. ppm	Tempera-ture, °C.	Per Cent Saturation	Cl⁻ ppm		Nitrates as N, ppm	. PO_4 ppm	Color, ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml.
							3'	Depth							
Mile 177.35 (cont'd)															
C Surface	9/10		-	3.0	28	38									
C 3'	9/10			3.1	28	39									
C 17'	9/10			2.0	28	25									
Mile 165															
C 3'	8/27		1.7	4.4	31	58	427		0.050	0.008	25	25	7.0	49	1,500
C 8'	8/27				30			(8')417							
C 3'	8/29		2.0	4.9	30	64	524		0.300	0.004	25	25	7.2	52	4,300
C 8'	8/29				30			(8')523							
C 3'	9/3		1.2	5.1	28	64	692		0.030	0.024	20	<25	7.1	58	9,300
C 3'	9/5		1.4	5.9	27	73	717		0.020	0.006	20	25	7.2	48	9,300
C 3'	9/9		1.3	5.3	29	69	679		0.030	0.002	25	28	7.3	54	7,500
Mile 153.5															
C 3'	8/27		2.2	6.9	33	95	309		0.050	<0.002	15	<25	7.3	53	91
C 8'	8/27				33			(8')311							
C 13'	8/27				32			(13')305							
C 18'	8/27				31			(18')306							
C 3'	8/29		1.1	4.9	31	65	382		0.300	0.004	25	<25	7.2	48	36
C 8'	8/29				31			(8') 391							
C 13'	8/29				31			(13')396							

C = Centerline

ARKANSAS-WHITE-RED FIELD STUDIES (Sheet 20 of 20)

Table E-4 - Individual Results, Sanitary Examination, Ouachita River, Mile 351.0 to 133.0

Station	Date Sampled	Ave. Daily Flow, CFS	5-day B.O.D. 20°C, ppm	D.O. ppm	Tempera-ture, °C.	Per Cent Saturation	Cl^- ppm		Nitrates as N, ppm	PO_4 ppm	Color, ppm	Turbidity ppm	pH	Total Alkalinity ppm	Coliforms MPN per 100 ml.
							3'	Depth							
Mile 153.5 (Contd)															
C 19'	8/29				30			(19') 389							
C 3'	9/3		1.2	6.1	28	77	590		0.030	<0.002	20	<25	7.1	52	140
C 3'	9/5		1.4	5.4	30	71	602		0.020	0.002	20	<25	7.1	52	430
C 3'	9/9		2.2	7.8	29	100	693		0.030	<0.002	15	25	7.3	48	930
Mile 133															
C 3'	8/27		2.3	6.7	32	91	195		0.100	0.004	15	<25	7.2	59	230
C 8'	8/27				32			(8') 193							
C 13'	8/27				32			(13') 195							
C 3'	8/29		2.2	6.6	31	88	197		0.300	<0.002	20	<25	7.3	54	150
C 8'	8/29				30			(8') 197							
C 11'	8/29				30			(11') 198							
C 3'	9/3		1.2	5.2	29	66	261		0.070	0.012	20	<25	7.1	56	150
C 3'	9/5		0.9	4.9	30	65	298		0.020	<0.002	20	<25	7.2	56	36
C 3'	9/9		1.5	6.1	30	80	397		0.150	0.004	15	<25	7.1	47	390

C = Centerline

Table E-5 - Ouachita River at Camden, Ark.

(Sheet 1 of 2)

Location - Water-stage recorder, lat. 33°35'49", long. 92°49'12", in SE 1/4 sec. 14, T. 13 S., R. 17 W., at bridge on U.S. Highway 79, half a mile northeast of Camden, Ouachita County, 0.4 mile downstream from St. Louis & Southwestern Railroad bridge. Datum of gage is 71.692 feet above mean sea level, datum of 1929, supplementary adjustment of 1941. Auxiliary staff gage at Cold Springs Bar, 6 miles upstream. Datum of auxiliary gage is 76.64 feet above mean sea level, datum of 1929.

Drainage Area - 5,390 square miles.

Average Discharge - 18 years (1928-29, 1930-33, 1934-48) 7,672 sec.ft.

Maximum - 1928-29, 1930-33, 1934-48, discharge 243,000 second-feet, April 3, 1945 (gage height 44.82 feet). Maximum stage known, 46.0 ft., May 12, 1882.

Minimum - 1928-29, 1930-33, 1934-48:
Day: 97 second-feet (62.7 MGD) August 4, 1930.
7-Day: 171 second-feet (111 MGD) Aug. 30 to Sept. 5, 1929.
Calendar Month: 217 second-feet (140 MGD) August, 1929.
Water Year: 2,884 second-feet (1,860 MGD) Oct. 1, 1930, to Sept. 30, 1931.

Date 1952	Average Daily Flow, cfs.	Mean Velocity ft/sec
July 15	526	
16	590	
17	690	
18	714	
19	728	
20	772	
21	775	
22	732	
23	706	
24	673	
25	679	
26	690	
27	664	
28	679	
29	817	0.76
30	792	
31	728	
Aug. 1	682	
2	740	
3	798	
4	811	0.75
5	822	
6	800	
7	776	
8	793	
9	968	
10	1,120	
11	1,150	0.94
12	820	
13	735	
14	690	
15	680	
16	778	
17	845	

Table E-5 (Continued)

(Sheet 2 of 2)

Date 1952	Average Daily Flow, cfs	Mean Velocity ft/sec
Aug. 18	845	0.75
19	780	
20	712	
21	622	
22	620	
23	778	
24	915	
25	1,040	0.90
26	818	
27	645	
28	600	
29	615	
30	670	
31	780	

Date 1952	Average Daily Flow, cfs	Mean Velocity ft/sec
Sept. 1	785	
2	722	0.68
3	640	
4	580	
5	520	
6	560	
7	610	
8	645	
9	824	0.77
10	820	
11	772	
12	865	
13	1,075	
14	1,150	
15	1,240	1.01

Flow data obtained from Corps of Engineers

Table E-6 - Ouachita River at Monroe, La.

Location - Wire-weight gage, lat. 32°30'19", long. 92°07'32", in lot 50, T. 18 N., R. 3 E., at bridge on U.S. Highway 80 at Monroe, 0.4 mile upstream from Illinois Central Railroad bridge and 5-1/2 miles upstream from Lock and Dam No. 4. Datum of gage is 31.40 ft. above mean sea level, datum of 1929, supplementary adjustment of 1941 (levels by Corps of Engineers). Auxiliary staff gage 5-1/2 miles downstream.

Drainage Area - 15,400 square miles (authority, Mississippi River Commission).

Maximum - 1938-50. Discharge 100,000 second-feet, April 12, 1945. Maximum gage height 50.42 feet, April 12, 1945.

Minimum - Discharge not determined (pool stage). Minimum gage height observed, 12.1 feet, Jan. 3, 1944.

Remarks - Records fair above 10,000 second-feet, and poor below. Stage-discharge relation below about 10,000 second-feet affected by operation of Lock and Dam No. 4.

Date, 1952	Average Daily Flow, cfs	Mean Velocity, ft/sec
July 9	1,390	0.34
16	1,130	
22	1,020	
30	866	
Aug. 6	821	
12	1,300	
20	1,310	
27	1,040	
Sept. 3	880	
9	791	0.2
24	904	

Flow data obtained from Corps of Engineers.

Table E-7 - Ouachita River - 5-Day B.O.D. at 20°C Results of Various Dilutions, Mile 341 to Mile 305

Station	Date 1952	5-Day B.O.D. at 20°C (ppm) Results of Various Dilutions			
		100%	50%	25%	10%
Mile 341	8/6	1.3		0.7	3.3
	8/8	2.4		2.9	
Mile 336	8/6			2.0	0.7
	8/7	0.5	2.4		
	8/8	> 1.62		3.3	
Mile 325	8/7	0.1	1.5		
Mile 316	8/7	0.7	1.4		
Mile 308	8/5	(Negative result)	3.0	4.8	
	8/6	0.2		4.2	
	8/7	0.0	5.6		
	8/8	0.2		4.6	
	8/11	(Negative result)	5.3	5.1	12.6
	8/14	0.3	5.1		
Mile 305	8/14		1.6		